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PROCEEDINGS
OF THE
SEVENTEENTH ANNUAL MEETING
HELD IN
NEW YORK CITY, JUNE 24 TO 26, 1909

Volume XVII

EDITED BY
HENRY S. MUNROE ARTHUR L. WILLISTON
HENRY H. NORRIS

ITHACA, N. Y.
OFFICE OF THE SECRETARY
CORNELL UNIVERSITY

1910



PRESS OF
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LANCASTER, PA.

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GEORGE W. ATHERTON.....	1904	July 24, 1906.	XIV, 292
VOLNEY G. BABBOUR.....	1894	June 4, 1901.	IX, 340
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JOSEPH A. THALER,

* Deceased.

LIST OF MEMBERS.

Revised to March 15, 1910.

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
ABBOTT, FREDERICK B..... 490 7th St., Brooklyn, N. Y.	Teacher of Mechanical Drawing, Brooklyn Manual Training High School	1904
ADAMS, CHARLES L..... Boston, Mass.	Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology.....	1904
ADAMS, COMFORT A..... Cambridge, Mass.	Professor of Electrical Engineering, Harvard University	1894
ADAMS, FRANK D..... 293 Mountain St., Montreal, Canada.	Dean of the Faculty of Applied Sci- ences, McGill University.....	1909
ADAMS, LEE FRANCIS..... State College, Pa.	Instructor in Electrical Engineering, Pennsylvania State College.....	1907
ADAMS, WALTER HOLBROOK Imperial Pei Yang University, Tientsin, China.	Professor of Mechanical Engineering..	1908
ALDERSON, VICTOR C..... Golden, Colo.	President, Colorado School of Mines..	1900
ALDRICH, WILLIAM S..... Potsdam, N. Y.	Director, Clarkson School of Tech- nology	1893
ALGER, PHILIP R..... 5 Maryland Ave., Annapolis, Md.	Professor of Mathematics, U. S. Navy	1909
ALLEN, C. FRANK..... Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Tech- nology	1893
ALLEN, CHARLES M..... 10 Dean St., Worcester, Mass.	Professor of Hydraulic Engineering, Worcester Polytechnic Institute....	1903
ALLEN, JOHN R..... 226 South Ingalls St., Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan.....	1907
ANDERSON, DOUGLAS S..... New Orleans, La.	Professor of Electrical Engineering, Tulane University.....	1900

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ANDERSON, F. PAUL..... Lexington, Ky.	Director, College of Mechanical and Electrical Engineering; Professor of Mechanical Engineering, State University of Kentucky.....	1894
ANTHONY, GARDNER C..... Tufts College, Mass.	Professor of Technical Drawing and Dean of Engineering School, Tufts College	1896
APPLETON, WILLIAM DAY.. Apartado 23, Zamora, Michoacan, Mexico.	Mechanical Engineer, The Guanajuato Power and Electric Co.....	1907
*APPLEYARD, LOUIS L..... 417 Ottawa St., East Lansing, Mich.	Assistant Professor of Mechanical Engineering, Michigan Agricultural College	1907
ARKLEY, LORNE M..... 318 N. Edgemont St., Media, Pa.	Assistant Professor of Engineering, Swarthmore College	1908
ARNOLD, BION J..... Chicago, Ill.	Consulting Electrical Engineer, Borland Building	1896
ASHLEY, GEORGE FRANCIS.. 47 Avon St., Somerville, Mass.	Instructor in Descriptive Geometry, Harvard College; Assistant Professor of Technical Drawing, Tufts College	1908
ATKINSON, FRED W..... 55 Pineapple St., Brooklyn, N. Y.	President of the Polytechnic Institute of Brooklyn	1905
ATKINSON, THOMAS W..... Baton Rouge, La.	Dean, College of Engineering, Louisiana State University.....	1907
AYARS, WILLIAM S..... Box 302, State College, Pa.	Associate Professor of Machine Design, The Pennsylvania State College.....	1907
AYER, ARTHUR W..... 3403 Gray's Ferry Road, Philadelphia, Pa.	General Superintendent, Harrison Bros. & Co., Inc.....	1894
AYER, FREDERIC E..... 16 Roslyn Flats, Cincinnati, Ohio.	Assistant Professor of Civil Engineering, University of Cincinnati.....	1907
AYRES, BROWN	President of the University of Tennessee	1898
*BABCOCK, EARLE J..... State University, Grand Forks, N. D.	Dean of the College of Mining Engineering and Professor of Chemistry and Metallurgy, State University and School of Mines of North Dakota...	1907

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BACON, GEORGE M..... 159 Pierpont Ave., Salt Lake City, Utah.	Civil Engineer	1907
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BALL, ALBERT Cooper Union, New York, N. Y.	Assistant Professor of Physics and Mechanical and Electrical Engineer- ing, Cooper Union for the Advance- ment of Science.....	1908
BALLARD, FREDERICK W.... 49 Cadwell Ave., Mayfield Heights, Cleveland, Ohio.	Manager of Engineering and Con- struction Department, The Sherwin- Williams Co.	1907
BALLOU, WILLARD A..... Brooklyn, N. Y.	Instructor in Mathematics, Pratt Institute of Brooklyn.....	1908
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BARBOWS, HAROLD K..... 6 Beacon St., Boston, Mass.	Hydraulic and Sanitary Engineer....	1902
BARBOWS, WILLIAM E., JR.. Chicago, Ill.	Assistant Professor of Electrical Engineering, Armour Institute of Technology	1903
BASQUIN, OLIN H..... Evanston, Ill.	Professor of Applied Mechanics. Col- lege of Engineering, Northwestern University	1903
BASS, FREDERIC H..... Minneapolis, Minn.	Assistant Professor of Municipal and Sanitary Engineering, University of Minnesota; Engineer, Minnesota State Board of Health.....	1904
*BATES, ERASTUS N..... East Lansing, Mich.	Instructor in Electrical Engineering, Michigan Agricultural College.....	1908

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BATES, ONWARD 355 Dearborn St., Chicago, Ill.	Civil Engineer	1903
BECKER, ALBERT JOHN..... 915 Belmont Ave., Grand Forks, N. D.	Professor of Applied Mathematics and Mechanical Drawing, State Univer- sity of North Dakota.....	1907
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BENTON, JOHN R..... Gainesville, Fla.	Professor of Physics and Electrical Engineering, University of Florida..	1905
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*BETTS, PHILANDER The Oakland, 2019 Columbia Road, Washington, D. C.	Assistant Professor in Electrical En- gineering, George Washington Uni- versity, Washington College of Engi- neering	1907
BEYER, SAMUEL W..... Ames, Iowa.	Vice-Dean, Division of Engineering and Professor of Geology and Mining Engineering, Iowa State College....	1899
*BIEGLER, PHILIP S..... 1917 Mansfield Ave., Spokane, Wash.	Assistant Professor of Electrical Engi- neering, State University of Iowa..	1903
BISHOP, FREDERIC LINDALL. Pittsburgh, Pa.	Professor of Physics, University of Pittsburgh.....	1907
BISSELL, GEORGE W..... East Lansing, Mich.	Dean of Engineering and Professor of Mechanical Engineering, Michigan Agricultural College	1894

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BITTING, HARRY STAHL... Williamson School P.O., Delaware Co., Pa.	General Director of Williamson Free School of Mechanical Trades.....	1909
BIXBY, WILLIAM H..... 428 Custom House, St. Louis, Mo.	Colonel Corps of Engineers, U. S. Army, U. S. Engineer's Office.....	1898
BLACK, ADOLPH New York, N. Y.	Adjunct Professor of Civil Engineer- ing, Columbia University.....	1907
BLANCHARD, ARTHUR H.... Providence, R. I.	Associate Professor of Civil Engineer- ing, Brown University.....	1902
BOARDMAN, HAROLD S. Orono, Me.	Professor of Civil Engineering, University of Maine.....	1903
*BOHANNAN, ROSSER D.... Indianola and 16th Aves., Columbus, Ohio.	Professor of Mathematics, Ohio State University.....	1907
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BOUGHTON, WILL H..... Morgantown, W. Va.	Professor of Civil Engineering, West Virginia University.....	1905
BOVEY, HENRY T..... South Kensington, London, England.	Rector of the Imperial College of Science and Technology.....	1892
BOWERMAN, MYRON R..... 913 Humboldt St., Manhattan, Kan.	Assistant in Mechanical Drawing, Kansas State Agricultural College..	1909
BOYD, ALFRED 1035 F St., Lincoln, Neb.	Adjunct Professor of Civil Engineer- ing, The University of Nebraska....	1909
BOYD, J. M. S. E..... 92 West Lane Ave., Columbus, Ohio.	Professor of Mechanics, Ohio State University.....	1907
BRACKETT, BYRON B..... Brookings, S. D.	Professor of Electrical Engineering, South Dakota State College.....	1906
BRADBURY, ROYALL DOUGLAS Technology Chambers, Boston, Mass.	Instructor in Civil Engineering, Massachusetts Institute of Tech- nology	1907
BRADFORD, JOSEPH N..... Columbus, Ohio.	Professor of Architecture, Ohio State University.....	1896
BRAY, CHARLES D..... Tufts College, Mass.	Professor of Mechanical Engineering, Tufts College	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BRECKENRIDGE, LESTER P... New Haven, Conn.	Professor of Mechanical Engineering, Sheffield Scientific School.....	1893
BREED, CHARLES B..... Boston, Mass.	Assistant Professor of Civil Engi- neering, Massachusetts Institute of Technology	1904
BRILL, GEORGE M..... 1134 Marquette Bldg., Chicago, Ill.	Mechanical, Electrical and Architec- tural Engineer.....	1894
BRINSMADE, ROBERT BRUCE. 4429 Morgan St., St. Louis, Mo.	Consulting Engineer	1907
BRISTOL, WM. HENRY..... Waterbury, Conn.	President, The Bristol Co.....	1909
BROOKE, WILLIAM E..... Minneapolis, Minn.	Professor of Mathematics and Me- chanics, College of Engineering, University of Minnesota.....	1902
BROOKS, J. ANSEL..... Providence, R. I.	Associate Professor of Mechanics and Mechanical Drawing, Brown Univer- sity	1904
BROOKS, JOHN P..... Urbana, Ill.	Associate Professor of Civil Engineer- ing, University of Illinois.....	1893
BROOKS, MORGAN	Professor of Electrical Engineering, University of Illinois.....	1899
BROWN, J. STANFORD..... 10 Belmont Ave., Yonkers, N. Y.	Vice-President and Treasurer, New York Realty Owners, 489 Fifth Ave., New York City.....	1903
BROWN, HENRY BAKER..... 303 Jefferson St., Valparaiso, Ind.	President, Valparaiso University.....	1903
*BROWN, N. H..... College Station, Texas.	Professor of Physics and Electrical Engineering, Agricultural and Me- chanical College of Texas.....	1904
BROWN, ROBERT L..... P. O. Box 416, Auburn, Ala.	Professor of Mining and Geology, Alabama Polytechnic Institute.....	1903
BROWNE, WM. HAND, JR... West Raleigh, N. C.	Professor of Physics and Electrical Engineering, North Carolina College of Agriculture and Mechanic Arts..	1899
BRUEGEL, A. THEODORE..... Philadelphia, Pa.	Manager, The Hesse-Bright Mfg. Co., 21st and Fairmount Ave., Philadel- phia, Pa.....	1900

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BRYANS, WM. REMINGTON.. P. O. Box 82, University Heights, N. Y.	Instructor in School of Applied Science, New York University.....	1908
BRYDONE-JACK, ERNEST E.. Winnipeg, Manitoba.	Professor of Civil Engineering, University of Manitoba.....	1902
BUMP, MILAN R..... Joplin, Mo.	Treasurer and General Manager, Empire District Electrical Company, Joplin, Missouri	1907
BURGESS, CHARLES F..... Madison, Wis.	Professor of Chemical Engineering, University of Wisconsin.....	1896
BURGHARDT, HENRY DWIGHT 457 Eastern Parkway, Brooklyn, N. Y.	Instructor in Machine Work, Pratt Institute	1909
BURLEY, J. W..... 170 St. James Place, Brooklyn, N. Y.	Instructor in Machine Work, Pratt Institute	1909
*BURNHAM, RAYMOND 3606 Prairie Ave., Chicago, Ill.	Associate Professor of Experimental Engineering, Armour Institute of Technology	1904
BURR, WILLIAM H..... New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
BURTON, ALFRED E..... Boston, Mass.	Professor of Topographical Engineering, in charge of Department of Drawing, and Dean, Massachusetts Institute of Technology.....	1904
BUTTERFIELD, ARTHUR D.... 10 Schussler Road, Worcester, Mass.	Assistant Professor of Mathematics, Worcester Polytechnic Institute....	1908
CADWELL, CHARLES ARTHUR 2072 E. 69th St., Cleveland, O.	Assistant Professor of Mining Engineering, Case School of Applied Science	1908
CAJORI, FLORIAN 1119 Wood Ave., Colorado Springs, Colo.	Professor of Mathematics and Dean of School of Engineering, Colorado College	1904
CALDERWOOD, JAMES PARK. State College, Pa.	Instructor in Mechanical Engineering, The Pennsylvania State College.....	1909
CALDWELL, EDWARD 239 West 39th St., New York, N. Y.	Treasurer, McGraw-Hill Book Co., New York City.....	1905
CALDWELL, FRANCIS C..... Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University.....	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
CALLAN, JOHN A. C..... 211 Seward Place, Schenectady, N. Y.	Instructor in Drawing and Civil Engineering, Union College, Union University	1909
CAMP, WALTER M..... 7740 Union Ave., Chicago, Ill.	Editor of <i>Railway and Engineering Review</i>	1904
CABHART, DANIEL	Civil Engineer	1902
Wilkensburg Station, Pittsburg, Pa.		
CARPENTER, LOUIS G..... Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
CARSON, WILLIAM W..... Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee.....	1894
CARTY, JOHN JOSEPH..... Short Hills, N. J.	Chief Engineer American Telephone and Telegraph Co., 15 Dey Street, New York City.....	1907
CHANDLER, CLARENCE A.... 24 Milk St., Boston, Mass.	Consulting Engineer	1902
CHANDLER, ELWYN F..... University, N. D.	Professor of Mathematics, University of North Dakota.....	1907
CHANUTE, OCTAVE	Consulting Engineer	1907
1138 Dearborn St., Chicago, Ill.		
CHASE, CHARLES H..... 39 Lincoln St., Stoneham, Mass.	Professor of Steam Engineering, Tufts College	1900
CHATBURN, GEORGE R..... Lincoln, Neb.	Professor of Applied Mechanics and Machine Design, University of Nebraska	1899
CHITTENDEN, RUSSELL H.... 83 Trumbull St., New Haven, Conn.	Director of the Sheffield Scientific School of Yale University.....	1908
CHRISTENSEN, GEORGE L.... Houghton, Mich.	Assistant Professor of Mechanical Engineering, Michigan College of Mines.	1905
CHRISTY, SAMUEL B..... Berkeley, Cal.	Professor of Mining and Metallurgy, University of California.....	1893
CLARK, ADDISON NEIL..... Reno, Nev.	Engineer of Mines, at present with <i>Nevada State Journal</i>	1907

MEMBERS.

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NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
CLARK, JOHN J..... 919 Sunset St., Scranton, Pa.	Dean of the Faculty, International Correspondence Schools; Manager Textbook Department International Textbook Company	1906
CLIFFORD, HARRY E..... 20 Crystal St., Newton Center, Mass.	Professor of Electrical Engineering, Harvard University	1907
CLIFTON, HARRY T..... 871 North Lake Ave., Pasadena, Cal.	Instructor in Physics, Throop Polytechnic Institute.....	1907
COBB, HERBERT E..... 2958 W. Adams St., Chicago, Ill.	Professor and Head of Department of Mathematics, Lewis Institute.....	1908
COLE, ARTHUR W..... 224 Waldron St., West Lafayette, Ind.	Assistant Professor in Mechanical Engineering, Purdue University....	1908
COMSTOCK, CLARENCE ELMER 522 Bradley Ave., Peoria, Ill.	Professor of Mathematics, Bradley Polytechnic Institute.....	1909
COMSTOCK, ELTING H..... 214 Beacon St., S. E. Minneapolis, Minn.	Professor of Mechanics and Mathe- matics, The School of Mines, Univer- sity of Minnesota.....	1907
COMSTOCK, FRANK MASON.. Cleveland, Ohio.	Professor of Descriptive Geometry, Case School of Applied Science.....	1907
CONNELLEY, CLIFFORD B.... Osgood and Maripoe Aves., Allegheny, Pa.	Dean of the School for Apprentices and Journeymen, Carnegie Technical Schools, Pittsburg, Pa.....	1907
CONRAD, LOWELL EDWIN... 603 Houston St., Manhattan, Kan.	Professor of Civil Engineering, Kansas State Agricultural College..	1908
CONSTANT, FRANK H..... Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota.....	1896
COOLEY, MORTIMER E..... Ann Arbor, Mich.	Professor of Mechanical Engineering and Dean of Department of Engi- neering, University of Michigan....	1893
CORTHELL, ELMER L..... 149 Broadway, New York, N. Y.	Civil Engineer	1895
COVELL, GRANT A..... Corvallis, Ore.	Dean of School of Engineering and Mechanic Arts, Oregon Agricultural College	1908

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
*COX, NELSON H..... Gainesville, Fla.	Professor of Civil Engineering, University of the State of Florida..	1903
CRAIGO, RALPH THURMAN.. 301 Johnson Ct., Madison, Wis.	Instructor in Mathematics, University of Wisconsin.....	1909
CRANDALL, CHARLES L.... Ithaca, N. Y.	Professor of Railroad Engineering, Cornell University	1893
CRANE, HAROLD G..... Boston, Mass.	Instructor in Electrical Engineering, Harvard University	1908
CREAGMILE, WM. B..... Norwood, Pa.	Assistant Professor of Experimental Electrical Engineering, Drexel Insti- tute, Philadelphia	1909
CREIGHTON, WILLIAM H. P.. 1445 Henry Clay Ave., New Orleans, La.	Professor of Mechanical and Sugar Engineering, Tulane University....	1893
CRENSHAW, BOLLING H.... Auburn, Ala.	Professor of Mathematics, Alabama Polytechnic Institute	1894
CRISSON, GEORGE	Instructor in Electrical Engineering, Stevens Institute of Technology....	1909
CROUCH, CALVIN HENRY.... 513 South Sixth St., Grand Forks, N. D.	Professor of Mechanical Engineering and Dean of College of Mechanical and Electrical Engineering, The State University of North Dakota..	1907
CURTIS, NORMAN PHILIP... 1216 Spring St., Madison, Wis.	Instructor in Railway Engineering, University of Wisconsin.....	1909
DALAKER, HANS H..... 523 Walnut St., S. E., Minneapolis, Minn.	Assistant Professor of Mathematics, University of Minnesota.....	1909
DALBURG, FRANK A..... Manila, P. I.	Surveyor, Bureau of Lands.....	1908
DALTON, B. J..... 1011 Indiana St., Lawrence, Kan.	Associate Professor of Railway Engi- neering, University of Kansas.....	1907
DANIELS, LESLIE NOEL.... Granite Quarry, Roan Co., N. C.	Granite Inspector for Chicago City Railway Co.	1908
DATES, HENRY B..... Cleveland, Ohio.	Professor of Electrical Engineering, Case School of Applied Science.....	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
DAVIS, ELLERY W..... Lincoln, Neb.	Dean of College of Arts and Science and Head Professor of Mathematics, University of Nebraska.....	1902
DAVIS, JAMES CHRISTOPHER 27 Lovell St., Worcester, Mass.	Instructor in Mechanical Drawing, Worcester Polytechnic Institute....	1909
DAVIS, JOHN CHARLES..... 178 14th St., Milwaukee, Wis.	Dean, College of Applied Science and Engineering, Marquette University..	1908
DEAN, ARTHUR D..... Albany, N. Y.	Chief, Division of Trades Schools, N. Y. State Education Department..	1907
DEFOE, LUTHER M..... Columbia, Mo.	Professor of Mechanics, University of Missouri.....	1904
DEIMEL, RICHARD F..... 146 Berkeley Place, Brooklyn, N. Y.	Assistant Professor of Mechanics, Stevens Institute of Technology....	1909
DELAY, FREDERIC A..... 212 S. College Ave., Fort Collins, Colo.	Professor of Electrical Engineering, State Agricultural College of Colo- rado	1909
DENISON, CHARLES S..... Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Mich- igan	1893
DENTON, FREDERICK W..... Painesdale, Mich.	General Manager of Mines, Copper Range Consolidated Company.....	1894
DENTON, JAMES E..... Hoboken, N. J.	Professor of Engineering Practice, Stevens Institute of Technology....	1893
DEPUY, CLARENCE E..... 411 N. Elmwood Ave., Oak Park, Ill.	Professor of Machine Design and Con- struction, Lewis Institute, Chicago..	1903
DERLETH, CHARLES, JR..... Berkeley, Cal.	Professor of Civil Engineering, and Dean of the College of Civil Engi- neering, University of California....	1904
DICKINSON, WM. ELMORE.. 334 Park St., Morgantown, W. Va.	Professor of Electrical Engineering, West Virginia University.....	1909
DIEMER, HUGO	Professor of Industrial Engineering, The Pennsylvania State College.....	1902
DIBKS, HENRY B..... 210 West Park St., Champaign, Ill.	Instructor in Mechanical Engineering, University of Illinois.....	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
DOHERTY, HENRY L..... 60 Wall St., New York, N. Y.	President, Denver Gas and Electric Company	1904
DOOLEY, CHANNING R..... 903 Center St., Wilksburg, Pa.	Engineer, Westinghouse Electric and Mfg. Co., and President of Casino Technical Night School.....	1907
DORSEY, JOHN W..... 214 West Lanvale St., Baltimore, Md.	Professor of Electrical Engineering, Clarkson Memorial School of Tech- nology	1909
DOWNTOWN, CHAS. EDWARDS 7309 Alice Ave., Swissvale, Pa.	Assistant Superintendent, Westing- house Electric and Manufacturing Company	1909
DEANE, WALTER H..... University, Miss.	Dean of the Department of Engineer- ing and Professor of Civil Engineer- ing, University of Mississippi.....	1903
DEINKER, HENRY S..... South Bethlehem, Pa.	President, Lehigh University.....	1905
DROWNE, HENRY B..... Box 3, East Side Sta., Providence, R. I.	Instructor in Civil Engineering, Brown University	1903
DU BOIS, A. JAY..... New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
† DUDLEY, CHARLES B..... P. O. Drawer 156, Altoona, Pa.	Chemist, Pennsylvania Railroad Com- pany	1894
DUFOUR, F. O..... Urbana, Ill.	Assistant Professor of Structural En- gineering, University of Illinois....	1906
DUKES, RICHARD G..... Lafayette, Ind.	Professor of Applied Mechanics, Purdue University	1907
*DUNCAN, LOUIS	Consulting Electrical Engineer.....	1904
56 Pine St., New York, N. Y.		
DUNCAN, MURRAY M..... Ishpeming, Mich.	Agent, Cleveland Cliffs Iron Co., and Member Board of Control, Michigan College of Mines.....	1905
DUNKIN, WILLIAM VAN.... 607 West High St., Urbana, Ill.	Instructor in Mechanical Engineering, University of Illinois.....	1908
DUNSTON, E. V..... 710 N. Carolina Ave., Washington, D. C.	Instructor in Mechanical Engineering, Assistant Professor of Civil Engineer- ing, George Washington University.	1909

† Deceased.

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
DURAND, WILLIAM F..... Stanford University, Cal.	Professor of Mechanical Engineering, Leland Stanford Junior University..	1899
EARLE, SAMUEL CHANDLER. 45 Sawyer Ave., Tufts College, Mass.	Professor of English (in the Engineer- ing School), Tufts College.....	1909
EASBY, WILLIAM, JR..... N. Jackson St., Media, Pa.	Professor of Municipal Engineering, University of Pennsylvania, Phila- delphia	1908
EBAUGH, W. CLARENCE..... 208 Douglas Ave., Salt Lake City, Utah.	Professor of Chemistry, University of Utah.....	1908
EDDY, HENRY T..... Minneapolis, Minn.	Dean of the Graduate School and Head Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota.....	1893
*EDDY, HORACE T..... 109 West Third St., Cincinnati, Ohio.	Machinery Sales Company.....	1903
EDMANDS, S. SUMNER..... Brooklyn, N. Y.	Head of Department of Applied Elec- tricity, Pratt Institute.....	1903
EGBERT, HERMAS V..... State College, Pa.	Instructor in Mechanics and Ma- terials of Construction, The Penn- sylvania State College.....	1907
ELLIOTT, JAMES W..... 41 South Prospect St., Burlington, Vt.	Assistant Professor of Civil Engineer- ing, University of Vermont.....	1908
EMORY, FREDERICK L..... Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia Univer- sity	1894
ENDERS, HENRY C..... New York, N. Y.	Assistant Professor of Chemistry, Cooper Union for the Advancement of Science	1908
ENDSLEY, LOUIS E..... 815 North 9th St., Lafayette, Ind.	Associate Professor of Railway Me- chanical Engineering, Purdue Uni- versity	1907
ENGER, MELVIN L..... 501 S. Babcock St., Urbana, Ill.	Associate in Municipal and Sanitary Engineering and Theoretical and Applied Mechanics, University of Illinois	1907
ENGLER, EDMUND A..... Worcester, Mass.	President of Worcester Polytechnic Institute	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
ENNIS, WILLIAM D..... Brooklyn, N. Y.	Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn...	1907
ENO, FRANK H..... 222 Sixteenth Ave., Columbus, Ohio.	Professor of Municipal Engineering, Ohio State University.....	1907
ESTERLINE, J. WALTER..... 145 Andrew Place, West Lafayette, Ind.	Associate Professor of Electrical En- gineering, Purdue University.....	1903
ESTY, WILLIAM South Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1898
EVANS, FREDERICK H..... 103 Ayres Ave., Peoria, Ill.	Instructor in Manual Arts, Bradley Polytechnic Institute.....	1907
EVANS, HENRY B..... College Hall, Philadelphia, Pa.	Assistant Professor of Mathematics, University of Pennsylvania.....	1903
EVANS, HERBERT S..... Boulder, Colo.	Professor of Electrical Engineering, University of Colorado.....	1905
EVANS, PEBCY NORTON..... 302 Waldron St., Lafayette, Ind.	Professor of Chemistry and Director of Chemical Laboratory, Purdue University	1903
EWINGER, M. I..... 804 Duff St., Ames, Iowa.	Assistant Professor of Civil Engineer- ing, Iowa State College.....	1909
EYBE, THOMAS T..... 501 Dodge St., W. Lafayette, Ind.	Instructor in Applied Mechanics, Purdue University	1909
FAIG, JOHN T..... 3, The Delmoor, Clifton, Cincinnati, O.	Professor of Mechanical Engineering, University of Cincinnati.....	1899
FARNHAM, CHARLES S..... 345 Winthrop Ave., New Haven, Conn.	Instructor in Civil Engineering, Shef- field Scientific School of Yale Uni- versity	1903
FABWELL, ELMER S..... 309 Broadway, New York, N. Y.	Consulting Engineer	1895
FEBGUSON, OLIN J..... 244 Parkwood Boulevard, Schenectady, N. Y.	Assistant Professor of Electrical En- gineering, Union College.....	1903
FERMIER, EMILE J..... College Station, Texas.	Professor of Mechanical Engineering, Texas Agricultural and Mechanical College	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
FERNALD, ROBERT H..... Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science.....	1899
FINE, HENRY BURCHARD.... The Dean's House, Princeton, N. J.	Professor of Mathematics, Dean of the Faculty and Dean of the Depart- ments of Science, Princeton Univer- sity	1909
FISH, FRED A..... Ames, Iowa.	Professor of Electrical Engineering, Iowa State College.....	1905
FISHER, JAMES, JR..... Houghton, Mich.	Professor of Mathematics and Physics, Michigan College of Mines.....	1899
FLATHER, JOHN J..... Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota.....	1893
FLEMING, VIRGIL R..... 306 E. Chalmers St., Champaign, Ill.	Instructor in Theoretical and Applied Mechanics, University of Illinois....	1909
FLETCHER, ROBERT Hanover, N. H.	Professor of Civil Engineering, Di- rector of Thayer School of Civil Engineering, Dartmouth College....	1894
FOCKE, THEODORE M..... 2057 Cornell Road, Cleveland, Ohio.	Kerr Professor of Mathematics, Case School of Applied Science.....	1907
FOGG, BENJAMIN G..... 22 Toppan St., Newburyport, Mass.	With Aberthaw Construction Co., Concrete Engineers and Contractors.	1907
FORD, ARTHUR H..... Iowa City, Iowa.	Professor of Electrical Engineering, State University of Iowa.....	1903
FORD, HOWARD CARLTON... Ames, Iowa.	Assistant Professor of Irrigation En- gineering and Surveying, Iowa State College	1907
FOSS, FRED E..... Pittsburg, Pa.	Professor of Civil Engineering, Cooper Union, New York City.....	1893
FOSS, MARTIN M..... Short Hills, N. J.	Secretary of the McGraw-Hill Book Company	1909
FOWLER, STERLING DEWITT. Berwick, Pa.		1907
FRANKEL, LEON KAUFMAN. 326 Aylesford Place, Lexington, Ky.	Professor of Machine Design, State University of Kentucky.....	1909
FRANKFORTER, GEORGE B.... Minneapolis, Minn.	Professor of Chemistry and Dean of the School of Chemistry, University of Minnesota	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
FRANKLIN, WILLIAM S.... Bethlehem, Pa.	Professor of Physics, Lehigh University	1900
FRARY, HOBART D..... 3108 Garfield Ave., So., Minneapolis, Minn.	Instructor in Engineering Mathe- matics, University of Minnesota....	1908
FREEDMAN, WILLIAM H.... 100 South Union St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont.....	1902
FREEMAN, ERNEST HARRISON 7026 South Park Ave., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology....	1909
FRENCH, ARTHUR W..... Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute....	1900
FRENCH, THOMAS E..... Columbus, Ohio.	Professor of Engineering Drawing, Ohio State University.....	1899
FRINK, FRED G..... Eugene, Ore.	Professor of Railway Engineering, University of Oregon.....	1902
FROST, ALBERT E..... 4527 Winthrop St., Pittsburg, Pa.	Acting Dean and Professor of Mathe- matics, Western University of Penn- sylvania	1908
FROST, G. HARWOOD..... 220 Broadway, New York, N. Y.	<i>Engineering News</i>	1907
FULLER, ALMON H..... University Station, Seattle, Wash.	Professor of Civil Engineering and Dean of the College of Engineering, University of Washington.....	1901
FULLER, CHARLES E..... Wellesley, Mass.	Associate Professor of Mechanical En- gineering, Massachusetts Institute of Technology	1907
FURMAN, FRANKLIN DER... 700 Hudson St., Hoboken, N. J.	Professor of Mechanism and Machine Design, Stevens Institute of Tech- nology	1907
GALBRAITH, JOHN	Professor of Engineering and Dean of the Faculty of Applied Science, Uni- versity of Toronto.....	1893
GANZ, ALBERT F..... Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute of Technology....	1903
GABMAN, HARRY O..... 2042 North Mer. St., Indianapolis, Ind.	Associate Professor of Civil Engineer- ing, Purdue University.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
GARRISON, WILBERT A..... 99 Van Vranken Ave., Schenectady, N. Y.	Assistant Professor of Engineering Mathematics, Union University.....	1908
GAVETT, GEORGE IRVING.... 5252 16th Ave., N. E.	Instructor in Mathematics, University of Washington.....	1907
GAY, ROBERT W..... 229 West Mulberry St., Fort Collins, Colo.	Associate Professor of Civil Engineer- ing, Colorado State Agricultural College	1907
GEHRING, HERBERT A..... 168 N. Allen St., Albany, N. Y.	Assistant Engineer, Bureau of Hy- draulics, N. Y. State Barge Canal Office	1907
*GEORGE, NATHAN R., JR... Boston, Mass.	Assistant Professor of Mathematics, Massachusetts Institute of Tech- nology	1907
*GIBBONS, CHARLES B..... 632 Central Bldg., Seattle, Wash.		1908
GIESECKE, F. E..... College Station, Texas.	Professor of Architectural Engineer- ing and Drawing, Texas Agricul- tural and Mechanical College.....	1893
GILL, AUTHOR HENDRIX.... Box 312, State College, Pa.	Associate Professor of Heat Engineer- ing, The Pennsylvania State College.	1909
GILL, JAMES H..... Urbana, Ill.	Assistant Professor of Machine Con- struction, University of Illinois.....	1896
GILLESPIE, PETER 63 Alexander St., Toronto, Ontario.	Lecturer on Applied Mechanics, University of Toronto.....	1905
GILLETTE, HALBERT P..... Park Row Building, New York, N. Y.	Managing Editor, <i>Engineering-Con- tracting</i>	1905
GLADSON, WILLIAM N..... Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas.....	1903
GOETZE, FREDERICK A..... New York, N. Y.	Dean of the Schools of Mines, Engi- neering and Chemistry, Columbia University	1906
GOODENOUGH, GEORGE A.... Urbana, Ill.	Associate Professor of Mechanical En- gineering, University of Illinois....	1900
GOSS, WILLIAM F. M..... Urbana, Ill.	Dean of the College of Engineering and Director, Engineering Experi- ment Station, University of Illinois.	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
GRANT, ELMER D..... Houghton, Mich.	Assistant Professor of Mathematics and Physics, Michigan College of Mines	1905
GREEN, BERNARD R..... 1738 N St., Washington, D. C.	Superintendent of Buildings and Grounds, Library of Congress.....	1906
GREEN, JAMES A..... Richfield, Idaho.	Const. Supt. for J. G. White & Co. on Idaho Irrigation Co. L'td project.	1904
GREENE, ARTHUR M., JR.... Troy, N. Y.	Professor of Mechanical Engineering, Rensselaer Polytechnic Institute....	1903
GREGORY, WILLIAM B..... 630 Pine St., New Orleans, La.	Professor of Experimental Engineering, The Tulane University of Louisiana; and Irrigation Engineer U. S. Department of Agriculture.....	1907
GROAT, BENJAMIN F..... Minneapolis, Minn.	Professor of Mechanics and Mathematics, School of Mines, University of Minnesota	1899
GROVER, NATHAN C..... 88 North 19th St., East Orange, N. J.	Construction Department, J. G. White & Co., 43 Exchange Place, New York, N. Y.	1894
GUNTHER, CHARLES O..... Hoboken, N. J.	Professor of Mathematics, Stevens Institute of Technology.....	1907
HALSEY, FREDERICK A..... 505 Pearl St., New York, N. Y.	Editor-in-Chief, <i>American Machinist</i> , Hill Publishing Company.....	1907
HAMERSCHLAG, ARTHUR A.. Pittsburg, Pa.	Director, Carnegie Technical Schools..	1903
HAMMER, MILBY RAY..... University Extension Division, Madison, Wis.	Instructor in Mechanical Drawing, University of Wisconsin, University Ex. Div.	1909
HANCOCK, EDWARD L..... Lafayette, Ind.	Assistant Professor of Applied Mechanics, Worcester Polytechnic Institute	1903
HARDING, C. FRANCIS..... 111 Fowler Ave., Lafayette, Ind.	Professor of Electrical Engineering and Director Electrical Laboratory, Purdue University	1908
HARING, ALEXANDER	Professor of Bridge and Railway Engineering, New York University....	1907
HARPER, CHAS. HAMILTON.. 1732 W. Broadway, Baltimore, Md.	Instructor in Drawing, Michigan Agricultural College	1909

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HARRINGTON, JOHN LYLE... Orear-Leslie Bldg., Kansas City, Mo.	Consulting Engineer, Waddell & Harrington	1903
HARRIS, ABRAM W..... Evanston and Chicago, Ill.	President, Northwestern University..	1897
HARTER, GEORGE A..... Newark, Del.	President of Delaware College.....	1908
HARTMANN, FRANCIS M... New York, N. Y.	Professor of Physics, Electrical and Mechanical Engineering, Cooper Union for the Advancement of Science.....	1908
HASKELL, EUGENE E..... Ithaca, N. Y.	Director, College of Civil Engineering, Cornell University	1907
HASKINS, CHARLES NELSON 46 South Main St., Hanover, N. H.	Assistant Professor of Mathematics, Dartmouth College	1909
HASTINGS, HUDSON B..... 69 Federal St., Brunswick, Me.	Assistant Professor in charge of Surveying and Drawing, Bowdoin College	1908
HATT, WILLIAM K..... Lafayette, Ind.	Professor of Civil Engineering and Director, Materials Testing Laboratory, Purdue University.....	1895
*HAVILAND, EDWIN, JR.... 4703 Brooklyn Ave., Seattle, Wash.	University of Washington.....	1902
HAWES, JOSEPH H..... 40 Fairmount St., Dorchester Center, Mass.	Teacher of Manual Training and Mechanical Drawing, Dorchester High School, Boston	1900
HAYFORD, JOHN F..... Evanston, Ill.	Director, College of Engineering, Northwestern University	1905
HAYNES, ARTHUR E..... Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota.....	1895
HAYWARD, HARRISON W.... Boston, Mass.	Assistant Professor of Applied Mechanics, Massachusetts Institute of Technology	1904
HECK, ROBERT C. H..... 192 College Ave., New Brunswick, N. J.	Professor of Mechanical Engineering, Rutgers College	1907
HEDRICK, IRA G..... Kansas City, Mo.	Consulting Engineer, Keith and Perry Building.....	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HENDRICK, ARCHER WILMOT 102 Otis St., Walla Walla, Wash.	Dean of Whitman College.....	1908
HENLEY, WILLIAM W..... Tucson, Ariz.	Professor of Mechanic Arts, University of Arizona.....	1907
HERGET, ALBERT M..... 453 Boyd Ave., Baton Rouge, La.	Professor of Drawing and Mechanic Arts, Louisiana State University...	1903
HIBBARD, ANGUS S..... 203 Washington St., Chicago, Ill.	2d Vice-President and General Man- ager, Chicago Telephone Company..	1907
HIBBARD, H. WADE..... Columbia, Mo.	Professor of Mechanical Engineering, University of Missouri.....	1896
HIGBEE, FRED. GOODSON.... Iowa City, Iowa.	Professor and Head of the Depart- ment of Descriptive Geometry and Drawing, State University of Iowa..	1906
HIGBIE, HENRY HAROLD.... 1109 E. University Ave., Ann Arbor, Mich.	Assistant Professor in Electrical En- gineering, University of Michigan...	1908
*HILL, JOHN E..... Providence, R. I.	Professor of Civil Engineering, Brown University	1894
HITCHCOCK, EMBURY A.... Columbus, Ohio.	Professor of Experimental Engineer- ing, Ohio State University.....	1899
HOAD, WILLIAM CHRISTIAN. Lawrence, Kan.	Associate Professor of Civil Engineer- ing, University of Kansas.....	1907
HODGKINS, HOWARD L..... 1830 T Street, Washington, D. C.	Dean College of Engineering and Mechanic Arts, George Washington University	1908
HOFFMAN, ARTHUR H..... 510 Clark Ave., Ames, Iowa.	Assistant Professor of Physics, Iowa State College of Agriculture and Mechanic Arts	1907
HOFFMAN, JAMES D..... 301 State St., West Lafayette, Ind.	Professor of Engineering Design, Purdue University	1907
HOFMAN, HEINRICH O..... Boston, Mass.	Professor of Metallurgy, Massachu- setts Institute of Technology.....	1894
HOLDEN, CHARLES A..... Hanover, N. H.	Professor of Civil Engineering, Thayer School of Civil Engineering, Dart- mouth College	1901
HOLDEN, EDWIN C..... Madison, Wis.	Professor of Mining Engineering, University of Wisconsin.....	1909

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HOLLIS, IRA N..... Cambridge, Mass.	Professor of Engineering, Harvard University	1894
HOLMES, JOSEPH A..... Washington, D. C.	Expert in charge, Technologic Branch United States Geological Survey....	1907
HOOD, OZNI P..... Houghton, Mich.	Professor of Mechanical and Elec- trical Engineering, Michigan College of Mines	1893
HOOPER, ELMER GUY..... 5912 A Bartmer Ave., St. Louis, Mo.	Instructor of Civil Engineering, Washington University	1909
HOOPER, WILLIAM L..... 124 Professor's Row, Tufts College, Mass.	Professor of Electrical Engineering, Tufts College	1907
HORMELL, WM. GARFIELD.. 268 N. Sandusky St., Delaware, Ohio.	Professor of Physics and Dean of men, Ohio Wesleyan University.....	1907
HOSKINS, LEANDER M..... 365 Lincoln Ave., Palo Alto, Cal.	Professor of Applied Mathematics, Leland Stanford Junior University..	1893
HOUGHTON, CHARLES E.... New York, N. Y.	Associate Professor Mechanical Engi- neering, New York University.....	1908
HOWARD, JOHN W..... 465 Washington St., Brookline, Mass.	Instructor in Civil Engineering, Mass- achusetts Institute of Technology...	1907
HOWE, CHARLES S..... Cleveland, Ohio.	President of Case School of Applied Science	1902
HOWE, MALVERD A..... Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute.....	1894
HUBBARD, ALBERT K... .. 1227 Ohio St., Lawrence, Kan.	Assistant Professor of Civil Engi- neering, University of Kansas.....	1907
HUDSON, CLARENCE W.... 5 West 82d St., New York, N. Y.	Professor of Civil Engineering, Poly- technic Institute of Brooklyn, N. Y..	1909
HUGHES, HECTOR J..... 114 Pierce Hall, Cambridge, Mass.	Assistant Professor of Civil Engineer- ing, Harvard University.....	1907
HUGHES, JOHN W..... 775 Hattie St., Schenectady, N. Y.	Assistant Professor of Civil Engineer- ing, Union University.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HUME, ALFRED University, Miss.	Vice-Chancellor and Professor of Mathematics, University of Mississippi	1894
HUMPHREYS, ALEXANDER C. Hoboken, N. J.	President of Stevens Institute of Technology	1903
HUMPHREYS, DAVID C..... Lexington, Va.	Dean of the School of Engineering and Professor of Civil Engineering, Washington and Lee University....	1893
HUNT, JOHN H..... Columbus, Ohio.	Associate Professor Electrical Engineering, Ohio State University....	1908
HUNTER, JOHN A..... Boulder, Colo.	Professor of Mechanical Engineering, University of Colorado.....	1904
HUNTINGTON, EDWARD V.... 27 Everett St., Cambridge, Mass.	Assistant Professor of Mathematics, Harvard University	1906
HUNTOON, LOUIS D..... 284 Orange St., New Haven, Conn.	Professor of Mining and Metallurgy, Sheffield Scientific School, Yale University	1908
HUTTON, SOL. E..... Box 651, U. S. P. O., Shanghai, China.	Professor of Electrical Engineering, Imperial Polytechnic College, Siccawai, Shanghai, China.....	1907
HYDE, A. LINCOLN..... Columbia Club, Columbia, Mo.	Assistant Professor of Bridge Engineering, University of Missouri....	1904
INGRAM, EDWARD L..... Philadelphia, Pa.	Assistant Professor of Railroad Engineering and Geodesy, University of Pennsylvania	1908
IRISH, LELAND WESLEY.... 808 Hamlin St., Evanston, Ill.	Assistant Professor of Civil Engineering, College of Engineering, Northwestern University	1909
IVES, HOWARD C..... Worcester, Mass.	Assistant Professor of Railroad Engineering, Worcester Polytechnic Institute	1901
JACKSON, DUGALD C..... Boston, Mass.	Professor of Electrical Engineering, Massachusetts Institute of Technology	1893
JACKSON, JOHN PRICE..... State College, Pa.	Dean of School of Engineering, The Pennsylvania State College.....	1894
JACOBUS, D. S..... 85 Liberty St., New York, N. Y.	Advisory Engineer, The Babcock & Wilcox Company	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
JACOBY, HENRY S..... Ithaca, N. Y.	Professor of Bridge Engineering, Cornell University	1894
JAMESON, JOSEPH M..... Brooklyn, N. Y.	Head of Department of Physics, Pratt Institute	1903
JENKINS, A. LEWIS..... 2350 Ohio Ave., Cincinnati, Ohio.	Assistant Professor of Mechanical En- gineering, University of Cincinnati..	1907
*JENSON, JOSEPH	Consulting Engineer, Office of State Engineer, Salt Lake City.....	1903
JEWETT, ARTHUR C..... Orono, Maine.	Professor of Mechanical Engineering, University of Maine.....	1907
JOHNSON, A. RITTENHOUSE. 83 Easton Ave., New Brunswick, N. J.	Instructor in Mathematics and Graph- ics, Rutgers College.....	1909
JOHNSON, JOHN S. A..... Blacksburg, Va.	Professor of Experimental Engineer- ing, Virginia Polytechnic Institute..	1907
*JOHNSON, JOHN W..... Lock Box 40, University, Miss.	Professor of Physics, University of Mississippi.....	1907
JOHNSON, LEWIS J..... Cambridge, Mass.	Professor of Civil Engineering, Harvard University	1898
*JOHNSTON, WILLIAM A.... Hillside Terrace, Belmont, Mass.	Associate Professor of Mechanical En- gineering, Massachusetts Institute of Technology	1907
JONES, BASSETT, JR..... 1 Madison Ave., New York, N. Y.	Consulting Engineer	1904
JONES, CLEMENT R..... Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University.....	1895
JONES, FORREST R..... 1702 Melrose Place, Knoxville, Tenn.		1893
JONES, FREDERICK S..... New Haven, Conn.	Dean of Yale College.....	1903
JUDD, HORACE	Associate Professor of Experimental Engineering, Ohio State University..	1907
KARAPETOFF, VLADIMIR	Professor of Electrical Engineering, Cornell University	1909

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
KAVANAUGH, WILLIAM H... Minneapolis, Minn.	Professor of Experimental Engineering, University of Minnesota.....	1902
KAY, EDGAR B..... University, Ala.	Dean, Department of Engineering; Professor of Civil Engineering, University of Alabama.....	1898
KELLY, WILLIAM Vulcan, Mich.	General Manager Penn Iron Mining Company, and Chairman Board of Control, Michigan College of Mines.	1905
KENERSON, WILLIAM H.... 100 Morris Ave., Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University.....	1903
KENNEDY, FRANK LOWELL.. 43 Appleton St., Cambridge, Mass.	Assistant Professor of Drawing and Machine Design, Harvard University.	1904
KENT, JAMES M..... Kansas City, Mo.	Instructor in Steam and Electricity, Manual Training High School of Kansas City	1903
KENT, WILLIAM 49 Union St., Montclair, N. J.	Consulting Engineer	1894
KENTON, ALFRED M..... 315 University St., West Lafayette, Ind.	Professor of Mathematics, Purdue University	1908
KENTON, OTIS ALLEN..... 239 W. 39th St., New York, N. Y.	Associate Editor, <i>Electrical World</i> ...	1909
KETCHUM, MILO S..... Crocker & Ketchum, 438 Century Bldg., Denver, Colo.	Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado.....	1903
KIDD, JOHN W..... College Station, Texas.	Associate Professor of Physics, Texas Agricultural and Mechanical College.	1909
KING, EVERETT EDGAR..... 412 Knobloch St., Stillwater, Okla.	Associate Professor of Civil Engineering, Oklahoma Agricultural and Mechanical College	1908
KING, ROY S. 43 Wroe Ave., Dayton, Ohio.	General Superintendent, Hall-Cronan Co.	1904
KINGSBURY, ALBERT East Pittsburg, Pa.	Mechanical Engineer with Westinghouse Electrical and Manufacturing Co.	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
KINSLEY, CARL 5454 Greenwood Ave., Chicago, Ill.	Associate Professor of Physics, University of Chicago.	1903
*KIRCHHOFF, CHARLES . . . 422 West End Ave., New York, N. Y.	General Manager and Vice-President, David Williams Company, Publishers	1907
*KLEIN, ARTHUR W. 158 South New St., Bethlehem, Pa.	Instructor in Mechanical Engineering, Lehigh University	1908
KNIGHT, CARL D. 194 Park Ave., Worcester, Mass.	Assistant Professor, Experimental Electrical Engineering, Worcester Polytechnic Institute	1907
KNIGHT, WILLIAM A. 206 West Lane Ave., Columbus, Ohio.	Associate Professor of Machine Shop Practice, Ohio State University. . . .	1907
KNIPP, CHARLES T. 913 West Nevada St., Urbana, Ill.	Assistant Professor of Physics, University of Illinois.	1907
KNOCH, JULIUS J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas.	1898
KNOTT, VIRGIL PROCTOR. . . 15 E. Spring St., Fayetteville, Ark.	Associate Professor of Civil Engineer- ing, University of Arkansas.	1909
KOCH, ERNEST H., JR. . . . Maplewood, N. J.	Instructor in Mathematics, Pratt Institute	1904
KORTRIGHT, FREDERIC L. . . 234 Jackson Ave., Morgantown, W. Va.	Professor of Chemistry, West Virginia University.	1907
KOTTCAMP, JOHN PAUL. . . 207 St. James Place, Brooklyn, N. Y.	Instructor in Steam and Strength of Materials, Pratt Institute.	1909
KUNZE, EDWARD J. Madison, Wis.	Instructor in Steam and Gas En- gineering, University of Wisconsin. .	1907
KYSER, HENRY H. Talladega, Ala.	Electrical Engineer	1897
*LADD, GEORGE E. Wilburton, Okla.	President, Oklahoma School of Mines and Metallurgy	1907
LAMBERT, BYRON J. 5 Fairchild St., Iowa City, Ia.	Professor of Structural Engineering, State University of Iowa.	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
LAMBERT, PRESTON A..... 215 South Center St., Bethlehem, Pa.	Professor of Mathematics, Lehigh University	1897
LANDBETH, OLIN H..... Schenectady, N. Y.	Professor of Civil Engineering, Union University	1893
LANGSDORF, ALEXANDER S.. St. Louis, Mo.	Professor of Electrical Engineering, Washington University	1903
LANZA, GAETANO	Professor of Applied Mechanics, in charge of the Department of Me- chanical Engineering, Massachusetts Institute of Technology.....	1893
LAWRANCE, CHARLES H.... 321 University St., West Lafayette, Ind.	Instructor in Mechanics, Purdue University	1906
LAWRENCE, CHARLES W.... 1203 W. 36th Place, Los Angeles, Cal.	Professor of Civil Engineering, Uni- versity of Southern California, Los Angeles, California	1909
LAWRENCE, JAMES W..... Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College.....	1898
LAWRENCE, RALPH R..... 34 Sumner St., Dorchester, Mass.	Associate Professor of Electrical En- gineering, Massachusetts Institute of Technology	1907
LAWRENCE, WILLIAM H.... 34 Sumner St., Dorchester, Mass.	Professor of Architectural Engineer- ing, Massachusetts Institute of Technology	1907
LAWS, FRANK ARTHUR..... Mass. Inst. of Tech., Boston, Mass.	Associate Professor of Electrical Test- ing, Massachusetts Institute of Tech- nology	1909
LEEDS, CHARLES C..... 5508 Elmer St., Pittsburg, Pa.	Head of Department of Drawing, School for Apprentices and Journey- men, Carnegie Technical Schools....	1907
LEETE, JOHN H..... Pittsburg, Pa.	Dean of the School of Applied Science, Carnegie Technical Schools.....	1907
LELAND, OBA MINER..... Cascadilla Building, Ithaca, N. Y.	Assistant Professor of Astronomy and Geodesy, Cornell University.....	1908
LEPAGE, CLIFFORD B..... P. O. Box 526, Stamford, Conn.	Assistant Professor of Physics, Stevens Institute of Technology....	1908
LEUTWILER, OSCAR ADOLPH. 511 West Green St., Urbana, Ill.	Assistant Professor of Machine De- sign, University of Illinois.....	1906

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
LEWIS, THOMAS KENYON... 128 W. 10th Ave., Columbus, O.	Assistant Professor of Engineering Drawing, Ohio State University....	1908
LINDEMANN, CHARLES A.... Lewisburg, Pa.	Professor of Applied Mathematics, Bucknell University	1905
LINVILLE, CLABENCE P.... State College, Pa.	Assistant Professor of Metallurgy, School of Mines and Metallurgy, The Pennsylvania State College.....	1904
LITTLE, CHARLES N..... 818 Elm St., Moscow, Idaho.	Professor of Civil Engineering, University of Idaho.....	1907
LOCKWOOD, EDWIN H..... 52 Division St., New Haven, Conn.	Assistant Professor of Mechanical En- gineering, Sheffield Scientific School, Yale University	1908
LODGE, W. LLOYD..... Box 402, East Lansing, Mich.	Assistant Professor of Physics, Michigan State Agricultural College.	1908
LONGYEAR, JOHN M..... Marquette, Mich.	Member Board of Control, Michigan College of Mines.....	1904
LORD, NATHANIEL W..... 338 West 8th Ave., Columbus, Ohio.	Professor of Metallurgy and Mineral- ogy and Director of the School of Mines, Ohio State University.....	1907
LOBY, CHARLES A..... 903 Stover St., Fort Collins, Colo.	President, State Agricultural College of Colorado	1908
LOVE, A. CAVITT..... Beaumont, Texas.	Construction Engineer, Beaumont Irrigating Company.....	1900
LUCKE, CHARLES EDWARD.. New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1906
LUDERITZ, JOAO	Engenheiro Chefe — Instituto Tech- nico Professional	1909
LUDY, LLEWELLYN V..... 229 University St., West Lafayette, Ind.	Professor of Mechanical Engineering, Purdue University	1903
LUNDBEN, E. L..... Manila, P. I.	Assistant Engineer, Bureau of Public Works	1907
LYMAN, RICHARD R..... 1084 Third Ave., Salt Lake City, Utah.	Professor of Civil Engineering, Uni- versity of Utah; Civil and Consult- ing Engineer	1908
MCAULIFFE, WM. JOSEPH.. 1300 Clay Ave., N. Y. City.	Professor of Sciences, Cathedral Col- lege	1908

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MCCAUSTLAND, ELMER J. 5264 19th Ave., N. E., Seattle, Wash.	Professor of Civil Engineering, University of Washington.....	1902
MCCOYMICK, EDMUND B.... 800 Houston St., Manhattan, Kan.	Professor of Mechanical Engineering and Dean of Mechanic Arts, Kansas State Agricultural College.....	1908
MCCONNELL, J. R..... Worcester, Mass.	Instructor in Mechanical Drawing, Worcester Polytechnic Institute....	1909
MCCOUBET, WALTER EDWARD Washington University, St. Louis, Mo.	Assistant Professor of Geology, Washington University	1909
MCDANIEL, ALLEN B..... Vermilion, S. Dak.	Professor of Civil Engineering, Uni- versity of South Dakota, and Con- sulting Civil Engineer and Architect	1907
MCKIBBEN, FRANK P..... South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1904
McMASTER, CARLOS LENOX. University of Illinois, Urbana, Ill.	Associate in General Engineering Drawing, Assistant to Dean of Men, University of Illinois.....	1908
McNAIR, FRED W..... Houghton, Mich.	President, Michigan College of Mines	1897
McNOWN, WILLIAM C..... 5½ So. First St., Walla Walla, Wash.	Civil Engineer	1907
McRAE, AUSTIN LEE..... 1202 State St., Rolla, Mo.	Professor of Physics, School of Mines and Metallurgy, University of Mis- souri	1907
McSCHELL, H. C..... Schenectady, N. Y.	Instructor in Civil Engineering, Union College, Union University.....	1909
*MACNAUGHTON, JAMES ... Calumet, Mich.	General Manager, Calumet and Hecla Mines, and Member Board of Con- trol, Michigan College of Mines.....	1905
MACK, JOHN G. D..... 110 East Johnson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wis- consin	1901
MACLAURIN, RICHARD C.... Boston, Mass.	President, Massachusetts Institute of Technology	1909
MACOMBER, GEORGE S..... Ithaca, N. Y.	Assistant Professor of Electrical En- gineering, Sibley College, Cornell University	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MAGNUSSON, C. EDWARD... University Station, Seattle, Wash.	Professor of Electrical Engineering, University of Washington.....	1907
MAGEUDEB, WILLIAM T.... Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University.....	1893
MAITLAND, ALEXANDER, JR.. Kansas City, Mo.	President of Kansas City Bridge Co..	1903
MALCOLM, CHARLES W.... 908 W. Nevada St., Urbana, Ill.	Assistant Professor of Structural En- gineering, University of Illinois....	1907
MARBURG, EDGAR Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania.....	1894
MARK, ROBERT M..... 211 Seward Place, Schenectady, N. Y.	Instructor in Engineering Mathe- matics, Union College.....	1909
MARKS, LIONEL SIMEON.... 88 Lake View Ave., Cambridge, Mass.	Professor of Mechanical Engineering, Harvard University	1909
MARSTON, ANSON Ames, Iowa.	Dean of the Division of Engineering and Professor of Civil Engineering, Iowa State College.....	1894
MARTENIS, JOHN VAN S.... Minneapolis, Minn.	Assistant Professor of Mechanical En- gineering, University of Minnesota..	1908
MARTIN, LOUIS A., JR..... 911 Castle Point Terrace, Hoboken, N. J.	Professor of Mechanics, Stevens Institute of Technology....	1907
MARTIN, THOS. COMMERFORD 29 W. 39th St., New York, N. Y.	Executive Secretary, National Elec- tric Light Association.....	1909
MARVIN, FRANK O..... Lawrence, Kan.	Dean of the School of Engineering and Professor of Civil Engineering, University of Kansas.....	1893
MARX, CHARLES D..... Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University..	1893
MATHEWS, HUBERT B..... Brookings, S. Dak.	Professor of Physics, South Dakota State College.....	1899
MATTHEWS, ROBERT CLAYTON Knoxville, Tenn.	Secretary, Tau Beta Pi Association and Assistant Professor Drawing and Machine Design, University of Tennessee	1908

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MAUREE, EDWARD R..... Madison, Wis.	Professor of Mechanics, University of Wisconsin.....	1897
MAXWELL, M. C..... Brooklyn, N. Y.	Head of Department of Applied Me- chanics, Pratt Institute.....	1908
MEAD, DANIEL W..... 1015 University Ave., Madison, Wis.	Professor of Hydraulic and Sanitary Engineering, University of Wiscon- sin	1908
MEAD, ELWOOD	Chairman, State Rivers and Water Supply Commission, Treasury Gar- dens	1901
MEASE, JAMES ALEXANDER. 108 S. Barnard St., State College, Pa.	Instructor in Machine Design, The Pennsylvania State College....	1909
MEEKER, WARREN H..... Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College.....	1903
MEES, C. LEO..... Terre Haute, Ind.	President, Rose Polytechnic Institute.	1894
MEHELY, COLOMAN	Associate of the Royal Hungarian Ministry of Commerce.....	1909
MEHTENS, A. CHRISTIAN.. 346 Holcomb Ave., Detroit, Mich.	Chief Engineer, Dodge Bros., Detroit..	1908
MEIKLEJOHN, ROBERT	Assistant Professor of Engineering Drawing, Ohio State University....	1909
MENDENHALL, THOMAS C... No. 3 via Palestro, Florence, Italy.	Mail to Worcester Polytechnic Insti- tute, Worcester, Mass.....	1895
MERRILL, ALLYNE L..... Hillside Terrace, Belmont, Mass.	Professor of Mechanism and Secretary of the Faculty, Massachusetts Insti- tute of Technology.....	1907
MERRILL, JOSEPH F..... Salt Lake City, Utah.	Director, Utah State School of Mines, Professor of Physics and Electrical Engineering, University of Utah....	1907
MERRIMAN, MANSFIELD 32 West 40th St., New York, N. Y.	Consulting Engineer	1893
MIGGETT, WILLIAM L..... 712 S. Thayer St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan.....	1902

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MILLER, DAYTON C..... Cleveland, Ohio.	Professor of Physics, Case School of Applied Science.....	1907
MILLER, HUGH 93 Main St., Potsdam, N. Y.	Professor of Civil Engineering, Clark- son Memorial School of Technology.	1909
MILLER, WILLIAM A..... 1949 E. 116th St., Cleveland, Ohio.		1908
MITCHAM, GEORGE NATHAN. Auburn, Ala.	Professor of Civil Engineering, Alabama Polytechnic Institute.....	1906
*MODJESKI, RALPH 5041 Washington Ave., Chicago, Ill.	Consulting Engineer	1908
MOLITOR, DAVID A..... Ithaca, N. Y.	Professor of Topographic and Geodetic Engineering, College of Civil Engi- neering, Cornell University.....	1907
MOORE, HERBERT F..... Urbana, Ill.	Assistant Professor of Theoretical and Applied Mechanics, University of Illinois	1905
MOORE, LEWIS E..... 85 Washington Park, Newtonville, Mass.	Assistant Professor of Civil Engineer- ing, Massachusetts Institute of Tech- nology	1907
MOORE, STANLEY H..... St. Louis, Mo.	Director, Mechanic Arts, McKinley High School	1902
MORE, CHARLES C..... University Station, Seattle, Wash.	Associate Professor of Civil Engineer- ing, University of Washington.....	1901
MORECROFT, J. HAROLD..... 122 St. James Place, Brooklyn, N. Y.	Instructor in Electrical Engineering, Columbia University	1908
MORETON, DAVID PENN..... 56 West 34th St., Chicago, Ill.	Associate Professor of Electrical En- gineering, Armour Institute of Tech- nology	1907
MORLEY, FRED Lapeer, Mich.	Civil Engineer	1896
MORRIS, CLYDE T..... 292 East 16th Ave., Columbus, Ohio.	Professor of Structural Engineering, Ohio State University.....	1907
MORRISON, CHARLES E..... New York, N. Y.	Instructor, Department of Civil Engi- neering, Columbia University.....	1907
MORSE, GEORGE H..... 632 North 25th St., Lincoln, Neb.	Professor of Electrical Engineering, University of Nebraska.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MOSELEY, ALEXANDER W... Chicago, Ill.	Professor of Mechanics, Head of Department of Engineering, Lewis Institute	1907
MOTT, WILLIAM ELTON.... c/o Carnegie Technical Schools, Pittsburg, Pa.	Professor of Civil Engineering, Carnegie Technical Schools.....	1907
MOYER, JAMES AMBROSE... Ann Arbor, Mich.	Assistant Professor of Mechanical Engineering, in charge of Mechanical Laboratories, University of Michigan	1904
MUNROE, GEORGE E..... 145 Barrett St., Schenectady, N. Y.	Construction Department, General Electric Co., Schenectady, N. Y.....	1907
MUNROE, HENRY S..... New York, N. Y.	Professor of Mining, School of Mines, Columbia University	1893
MUNROE, JAMES P..... 79 Summer St., Boston, Mass.	Treasurer, Munroe Felt and Paper Co., Secretary of Corporation of Massachusetts Institute of Technology....	1904
*MYERS, RALPH E..... State College, Pa.	Assistant Professor of Electro-chemical Engineering, The Pennsylvania State College	1907
NAGLE, JAMES C..... College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
NEFF, FRANK H..... Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science.....	1895
NELSON, ALLEN HENRY.... 64-66 5th Ave., New York, N. Y.	Manager of College Department, The Macmillan Co.....	1909
NESBIT, ARTHUR F..... Durham, N. H.	Professor of Physics, New Hampshire College of Agriculture and Mechanic Arts	1902
NEWKIRK, BURT L..... 1016 29th Ave., N. E., Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota.....	1903
NEWTON, JAMES DYNAN... 1536 New Hampshire St., Lawrence, Kan.	Assistant Professor of Civil Engineering, University of Kansas.....	1903
NICHOLS, GEN. EDWARD W.. Lexington, Va.	Superintendent, Virginia Military Institute	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
NOBLE, HENRY P..... 912 Forest Ave., Ann Arbor, Mich.	Instructor in Machine Design and Assistant to Superintendent of Shops, University of Michigan.....	1908
NORRIS, EARLE B..... 301 Johnson Court, Madison, Wis.	Assistant Professor of Mechanical Engineering, Extension Division, University of Wisconsin.....	1907
NORRIS, HENRY H..... Ithaca, N. Y.	Head Professor of Electrical Engineering, Cornell University.....	1900
NORTH, HERBERT B..... 250 Whaley Ave., New Haven, Conn.	Instructor of Machine Design and Descriptive Geometry, Sheffield Scientific School, Yale University.....	1908
NORTON, CHARLES L..... Hudson, N. H.	Associate Professor of Physics, Massachusetts Institute of Technology....	1908
NORWOOD, CHARLES JOSEPH. 339 Aylesford Place, Lexington, Ky.	Dean, College of Mining Engineering, State University of Kentucky.....	1907
NOYES, ARTHUR A..... Boston, Mass.	Professor of Theoretical Chemistry, Mass. Institute of Technology.....	1907
NOYES, ROBERT E..... 41 Madison St., Brooklyn, N. Y.	Instructor in Applied Electricity, Pratt Institute	1909
NUNN, PAUL N..... Provo, Utah.	Chief Engineer, The Telluride Power Co., The Ontario Power Co., and Consulting Engineer	1907
O'BYRNE, J. F..... Dahlonega, Ga.	Professor of Mining and Electrical Engineering, N. G. A. College.....	1905
OHLE, ERNEST L..... St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1905
OLSEN, TINNIUS	Mechanical Engineer	1907
500 North 12th St., Philadelphia, Pa.		
ORTON, EDWARD, JR..... Columbus, Ohio.	Professor of Ceramic Engineering and Dean of the College of Engineering, Ohio State University.....	1900
OSBORN, FREDERICK A..... 5215 15th Ave., N. E., Seattle, Wash.	Professor of Physics, University of Washington.....	1907
OSTRANDER, JOHN E..... Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
OSTRUP, JOHN C..... 203 West 103d St., New York, N. Y.	Professor of Structural Engineering, Stevens Institute of Technology....	1907
OWENS, ROBERT B..... Charlotte, N. C.	Southern Power Co., Charlotte, N. C..	1894
PALMER, THOMAS W..... Montevallo, Ala.	President of the Alabama Girls' In- dustrial School	1905
PALMER, WALTER K..... 718 Dwight Building, Kansas City, Mo.	The W. K. Palmer Co., Engineers, Kansas City, Mo.....	1899
PARK, CHARLES F..... 21 Prospect St., Taunton, Mass.	Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology; Director of Lowell Institute School for Industrial Fore- men	1903
PARKER, LAWRENCE G..... 107 E. Green St., Champaign, Ill.	Associate (in Civil Engineering), University of Illinois.....	1907
PATTERSON, ANDREW H..... Chapel Hill, N. C.	Professor of Physics, University of North Carolina.....	1907
PAUL, CHARLES E..... Chicago, Ill.	Associate Professor of Mechanics, Armour Institute of Technology....	1907
PECK, MYRON H..... c/o Dr. A. P. Peck, Tientsin, North China.	Professor of Civil Engineering, Imperial Pei Yang University.....	1909
*PENCE, WILLIAM D..... Madison, Wis.	Professor of Railway Engineering, University of Wisconsin.....	1895
PENDER, HAROLD	Professor of Theoretical and Applied Electricity, Massachusetts Institute of Technology	1909
PERRY, CHARLES FREDERICK 3416 Cedar St., Milwaukee, Wis.	Supervisor of Manual and Industrial Training, Milwaukee Public Schools.	1907
PETTEE, CHARLES H..... Durham, N. H.	Professor of Mathematics, New Hampshire College.....	1898
PHELON, JOSEPH O..... 27 Schussler Road, Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1902
PHETTEPLACE, THURSTON M. 1612 Broad St., Providence, R. I.	Assistant Professor of Mechanical En- gineering, Brown University.....	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
PHILLIPS, JAMES D..... Madison, Wis.	Professor of Drawing, University of Wisconsin.....	1899
PIERCE CHARLES H..... 15 Adsit Place, Burlington, Vt.	Assistant Professor of Railroad Engi- neering and Mechanics, University of Vermont	1906
PLUMB, HYLON T..... 401 Russell St., Lafayette, Ind.	Associate Professor of Electrical En- gineering, Purdue University.....	1907
POLSON, JOSEPH A..... Box 166, East Lansing, Mich.	Assistant Professor in Mechanical Engineering, Michigan Agricultural College	1907
POOLE, CECIL P..... 36 West End Road, South Orange, N. J.	Editor, <i>Power and the Engineer</i>	1907
*POORMAN, ALFRED P..... 1133 Pleasant St., Boulder, Colo.	Instructor in Civil Engineering, University of Colorado.....	1907
PORTER, DWIGHT	Professor of Hydraulic Engineering, Massachusetts Institute of Tech- nology	1893
PORTER, J. MADISON..... Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
PORTER, JOHN B..... Montreal, Quebec.	Professor of Mining Engineering, McGill University	1904
PORTER, ROYAL A..... 112 Livingston Ave., Syracuse, N. Y.	Associate Professor of Physics, Syracuse University	1908
POTTER, ANDREY A..... Kansas State Agricul- tural College, Manhattan, Kan.	Professor of Steam and Gas Engi- neering, Kansas State Agricultural College	1908
*POWELL, EMERY H..... 1538 Madison Ave., Scranton, Pa.	Engineering Textbook Writer, Inter- national Correspondence Schools....	1903
PRATT, CHARLES M..... Brooklyn, N. Y.	President, Board of Trustees, Pratt Institute	1907
PRATT, FRANK RANDALL... Box 469, New Brunswick, N. J.	Instructor in Physics, Rutgers College.	1909
PRATT, FREDERIC B..... Brooklyn, N. Y.	Secretary, Pratt Institute.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
PRATT, GEORGE D..... 245 Clinton Ave., Brooklyn, N. Y.	Treasurer, Pratt Institute.....	1909
PRATT, JAMES ALFRED..... Williamson School, Delaware Co., Pa.	Director, Williamson Free School of Mechanical Trades	1908
PRICE, FRANK O..... Brooklyn, N. Y.	Instructor in Strength of Materials, Pratt Institute	1909
*PRICE, MELVIN	Lafayette, Ind.	1900
PRYOR, FREDERICK L..... 421 4th Ave., Newark, N. J.	Professor of Experimental Engineer- ing, Stevens Institute of Technology.	1908
PULLEN, MYRICK W..... Iowa State College, Ames, Iowa.	Instructor in Electrical Engineering, Iowa State College of Agriculture and Mechanic Arts.....	1909
*PUPIN, MICHAEL I..... New York, N. Y.	Professor of Electromechanics, Columbia University	1895
PURYEAB, CHARLES	Dean and Professor of Mathematics, Agricultural and Mechanical Col- lege of Texas.....	1901
QUERBACH, EARL	Instructor in Bridge Engineering, University of Missouri.....	1909
*RADTKE, ALBERT A..... 244 47th St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology....	1907
RANDALL, OTIS E..... Providence, R. I.	Professor of Mechanics and Mechan- ical Drawing, Brown University....	1903
RANDOLPH, LINGAN S..... Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute.....	1904
RANSOM, JAMES H..... 323 University St., West Lafayette, Ind.	Professor of General Chemistry, Purdue University	1904
RAUTENSTRAUCH, WALTER .. New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1907
RAY, FRANKLIN A..... 6 Deshler Block, Columbus, Ohio.	Professor of Mine Engineering, Ohio State University.....	1886

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RAYMOND, HOWARD M..... Chicago, Ill.	Dean of Engineering Studies and Professor of Experimental Physics, Armour Institute of Technology....	1904
RAYMOND, WILLIAM G..... Iowa City, Iowa.	Dean of College of Applied Science and Professor of Civil Engineering, State University of Iowa.....	1893
REBER, LOUIS E..... Madison, Wis.	Director, University Extension, University of Wisconsin.....	1893
REID, CLARENCE E..... P. O. Agricultural College, Miss.	Professor of Physics and Electrical Engineering, Mississippi Agricultural and Mechanical College.....	1907
RICE, HERBERT A..... 1233 Massachusetts St., Lawrence, Kan.	Associate Professor of Civil Engineering, University of Kansas.....	1907
RICHARDS, CHARLES RUSS.. Lincoln, Neb.	Dean of the College of Engineering and Professor of Mechanical Engineering, The University of Nebraska.	1895
RICHARDS, CHAS. RUSSELL. New York, N. Y.	Director, Cooper Union.....	1904
RICHARD, DEAN W..... Sampsel, Okla.		1909
RICHARDS, ROBERT H..... Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
RICHEY, ALBERT S..... 9 Regent St., Worcester, Mass.	Professor of Electric Railway Engineering, Worcester Polytechnic Institute	1907
RICHTER, ARTHUR W..... Missoula, Montana.	Professor of Engineering, in charge of School of Engineering, University of Montana	1894
RICKER, N. CLIFFORD..... Urbana, Ill.	Professor of Architecture, University of Illinois; President, Illinois Board of Examiners of Architects.....	1894
RIESENBERGER, ADAM 546 Union Place, Weehawken, N. J.	Registrar and Treasurer, Stevens Institute of Technology.....	1904
RIGGS, NORMAN C..... Pittsburg, Pa.	Assistant Professor of Mathematics, Carnegie Technical Schools.....	1907
RIGGS, WALTER M..... Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Department of Engineering, Clemson (A. and M.) College of South Carolina.....	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RITTENHOUSE, LEON H..... Haverford, Pa.	Associate Professor, Haverford College	1906
ROBBINS, ARTHUR G..... Boston, Mass.	Professor of Topographical Engineering, Massachusetts Institute of Technology	1894
ROBERTS, W. J..... Medford, Oregon.	Consulting Engineer	1903
ROBINSON, EDWARD	Professor of Mechanical Engineering, University of Vermont.....	1899
ROBINSON, FREDERIC H..... Newark, Del.	Professor of Civil Engineering, Delaware College	1894
ROBINSON, STILLMAN W.... 515 W. First Ave., Columbus, Ohio.	Mechanical Engineer and Expert, Emeritus Professor of Mechanical Engineering, Ohio State University, President, S. W. Robinson Machine Company	1893
ROCKWELL, EDWARD H..... 133 Powder House Blvd., Somerville, Mass.	Professor of Structural Engineering, Tufts College	1907
RODHOUSE, THOMAS J..... Columbia, Mo.	Assistant Professor of Hydraulic Engineering, University of Missouri...	1904
ROE, JOSEPH W..... 79 Trumbull St., New Haven, Conn.	Instructor in Mechanical Engineering, Sheffield Scientific School, Yale University	1908
ROEBER, E. F..... 26 Amherst St., East Orange, N. J.	Editor, <i>Electrochemical and Metallurgical Industry</i>	1909
*ROGERS, RALPH	Assistant Professor of Engineering Drawing, Ohio State University....	1908
RONDINELLA, LINO F..... 4043 Walnut St., Philadelphia, Pa.	Head of Drawing Department, Central Manual Training High School of Philadelphia	1903
ROSEBROUGH, THOMAS R.... Toronto, Ontario.	Professor of Electrical Engineering, University of Toronto.....	1896
ROWLAND, ARTHUR J..... 4510 Osage Ave., Philadelphia, Pa.	Director of the School of Engineering, Professor of Electrical Engineering, Drexel Institute	1903
RUGAN, HENRY F..... 1468 Nashville Ave., New Orleans, La.	Associate Professor of Mechanic Arts and Erecting Engineering, Tulane University of Louisiana.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RUGG, HAROLD O..... 848 West William St., Decatur, Ill.	Instructor in Civil Engineering, The James Millikin University.....	1909
RUSSELL, WALTER B..... Berkeley & Appleton Sts., Boston, Mass.	Director, Franklin Union.....	1903
RYAN, HARRIS J..... Stanford University, Cal.	Professor of Electrical Engineering, Leland Stanford Junior University..	1901
SADLER, HERBERT C..... 705 South State St., Ann Arbor, Mich.	Professor of Naval Architecture and Marine Engineering, University of Michigan	1907
SANBORN, FRANK E..... Columbus, Ohio.	Professor, Industrial Arts Depart- ment, Ohio State University.....	1899
SANFORD, CLARENCE HORTON 9 Hamilton St., Potsdam, N. Y.	Professor of Mechanical Engineering, Thomas S. Clarkson Memorial School of Technology	1909
SATTERFIELD, HOWARD E... West Raleigh, N. C.	Professor of Mechanical Engineering, North Carolina College of Agricul- ture and Mechanic Arts.....	1909
SAWYER, ARTHUR R..... East Lansing, Mich.	Professor of Physics and Electrical Engineering, Michigan Agricultural College	1907
SCHAPHORST, WILLIAM F... Agricultural College, New Mexico.	Assistant Professor Mechanical Engi- neering, New Mexico College of Agriculture and Mechanic Arts.....	1908
SCHMIDT, EDWARD C..... 903 W. California Ave., Urbana, Ill.	Associate Professor of Railway Engi- neering, University of Illinois.....	1907
SCHNEIDER, HERMAN Cincinnati, Ohio.	Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati.....	1903
SCHUERMAN, WILLIAM H... Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Van- derbilt University	1895
SCOTT, ARTHUR C..... Austin, Tex.	Professor of Electrical Engineering, University of Texas; Consulting Engineer	1903
SCOTT, CHARLES F..... Pittsburg, Pa.	Consulting Engineer, Westinghouse Electric and Manufacturing Com- pany	1904
SCRUGHAM, JAMES G..... Reno, Nev.	Professor of Mechanical Engineering, Nevada State University.....	1906

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SEARS, THOMAS B..... Civil Engineering Bldg., Berkeley, Cal.	Associate Professor of Railway Engineering, University of California...	1908
SEAYER, HENRY L..... 491 Boylston St., Boston, Mass.	Assistant Professor of English, Massachusetts Institute of Technology....	1896
SEDGWICK, WILLIAM T.... Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology.....	1896
SEERY, FRANCIS J..... 25 Willard Ave., University Place, Ithaca, N. Y.	Assistant Professor of Civil Engineering, College of Civil Engineering, Cornell University	1908
SEVER, GEORGE F..... New York, N. Y.	Professor of Electrical Engineering, Columbia University	1903
SEXTON, FREDERIC H..... Halifax, Nova Scotia.	President, Nova Scotia Technical College, and Director of Technical Education	1908
SEYFERT, STANLEY S..... 456 Chestnut St., So. Bethlehem, Pa.	Assistant Professor in Electrical Engineering, Lehigh University.....	1908
SHAAD, GEORGE C..... 1622 New Hampshire St., Lawrence, Kan.	Professor of Electrical Engineering, University of Kansas.....	1907
SHANE, ADOLPH	Associate Professor of Electrical Engineering, Iowa State College.....	1907
SHATTUCK, HAROLD BEMIS. State College, Pa.	Associate Professor of Civil Engineering, The Pennsylvania State College.	1906
SHAW, HOWARD B..... 511 Rollins Road, Columbia, Mo.	Dean of School of Engineering, Director of Engineering, Experiment Station, University of Missouri.....	1907
SHAW, JAMES BYRNIE..... 1258 W. Macon St., Decatur, Ill.	Professor in Mathematics, James Millikin University.....	1909
SHEALY, EDWARD M..... 2134 West Lawn Ave., Madison, Wis.	Instructor in Steam and Gas Engineering, University of Wisconsin....	1909
SHELDON, SAMUEL	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn	1903
SHENEHON, FRANCIS C.... 323 11th Ave., S. E., Minneapolis, Minn.	Dean, College of Engineering, University of Minnesota.....	1909

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SHEPARDSON, GEORGE D.... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota.....	1895
*SHERMAN, CHRISTOPHER E. 230 West 10th Ave., Columbus, Ohio.	Professor of Civil Engineering, Ohio State University.....	1907
SHIPLEY, SYLVANUS CARL.. 113 State St., S. E., Minneapolis, Minn.	Assistant Professor in Mechanical engineering, University of Minnesota.	1908
SHOOP, CHARLES FRANKLIN Minneapolis, Minn.	Instructor in Experimental Engineer- ing, University of Minnesota.....	1906
SHORT, ROBERT L..... Cleveland, Ohio.	Mathematics Department, Technical High School	1902
SHOUDY, WILLIAM A..... 520 Hudson St., Hoboken, N. J.	Assistant Professor of Experimental Engineering, Stevens Institute of Technology	1907
SHUSTER, JOHN W..... 235 West Gilman St., Madison, Wis.	Assistant Professor of Electrical En- gineering, University of Wisconsin..	1907
SLICHTER, CHARLES S..... Madison, Wis.	Professor of Applied Mathematics, University of Wisconsin; Consult- ing Engineer, U. S. Reclamation Service	1906
SLIPPY, RALPH B..... 102 South Romine St., Urbana, Ill.	Instructor in Civil Engineering, University of Illinois.....	1907
SLOCUM, ROY H..... Agricultural College, N. D.	Professor of Civil Engineering, North Dakota Agricultural College.....	1903
SLOCUM, STEPHEN E..... Cincinnati, Ohio.	Professor of Applied Mathematics, University of Cincinnati.....	1906
SMART, GEORGE	Editor, <i>Iron Trade Review</i>	1907
SMITH, ALBERT W..... 1971 E. 79th St., Cleveland, Ohio.	Professor of Metallurgy, Case School of Applied Science.....	1904
SMITH, ALTON L..... Worcester, Mass.	Professor of Drawing and Machine Design, Worcester Polytechnic Insti- tute	1902
SMITH, ANSON W..... Brooklyn, N. Y.	Instructor in Mechanical Drawing, Pratt Institute	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SMITH, ARTHUR GEORGE.... West Side, Iowa City, Ia.	Head of Department of Theoretical Mechanics, State University of Iowa.	1909
SMITH, EARL B..... Philadelphia, Pa.	Assistant Professor of Experimental Mechanical Engineering, Drexel In- stitute	1906
SMITH, HAROLD B..... Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1898
SMITH, HARRY E..... 1346 West Wood St., Decatur, Ill.	Professor of Mechanical Engineering, James Millikin University.....	1895
SMITH, HERBERT S. S..... Princeton, N. J.	Professor of Civil Engineering, Princeton University	1894
SMITH, LEONARD S..... 939 University Ave., Madison, Wis.	Associate Professor of Topographic and Geodetic Engineering, Univer- sity of Wisconsin.....	1903
SMITH, LLOYD B..... Pittsburg, Pa.	Instructor in Geology, School of Ap- plied Science, Carnegie Technical School	1909
SMITH, PERCY F..... 330 Willow St., New Haven, Conn.	Professor of Mathematics, Sheffield Scientific School, Yale University...	1908
SMULL, THOMAS J., JR.... Ada, Ohio.	Dean of the College of Engineering and Professor of Civil Engineering, Ohio Northern University.....	1907
SMYTH, HENRY L..... 9 Buckingham St., Cambridge, Mass.	Professor of Mining and Metallurgy, Harvard University	1907
SNOW, CHARLES H..... New York, N. Y.	Dean of School of Applied Science, and Professor of Civil Engineering, New York University.....	1895
SNOW, WALTER B..... 29 Russell Ave., Watertown, Mass.	Publicity Engineer, 170 Summer St., Boston, Mass.	1899
SOLBERG, HALVOR C..... Brookings, S. D.	Professor of Mechanical Engineering, South Dakota State College of Agri- culture and Mechanic Arts.....	1894
*SONGE, ADOLPH	Mechanical Engineer, Chicago, Ill....	1907
SPALDING, FREDERICK P.... Columbia, Mo.	Professor of Civil Engineering, Uni- versity of Missouri.....	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SPANGLER, HENRY W..... Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania.....	1895
SPARKS, EDWIN EBEL..... State College, Pa.	President, The Pennsylvania State College	1908
SPEER, FREDERICK W..... Houghton, Mich.	Professor of Civil and Mining Engi- neering, Michigan College of Mines..	1896
SPINNEY, LOUIS B..... Ames, Iowa.	Professor of Physics and Illuminating Engineering, Iowa State College....	1899
SPOFFORD, CHARLES M..... Boston, Mass.	Hayward Professor of Civil Engineer- ing, Massachusetts Institute of Technology	1904
SPRINGER, FRANK W..... University of Minnesota, Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota.....	1896
STANFORD, J. VERNE..... Univ. of Pennsylvania, Philadelphia, Pa.	Assistant Professor of Mechanical Engineering, University of Pennsyl- vania	1907
*STANWOOD, JAMES B..... Cincinnati, Ohio.	Vice-President and Engineer, Hous- ton, Stanwood & Gamble Company..	1894
STEEL, ALVIN A..... Fayetteville, Ark.	Professor of Mining, University of Arkansas	1905
STEVENS, EDWARD F..... Brooklyn, N. Y.	Head of Applied Science Reference Department, Pratt Institute Free Library	1908
STEWART, CHARLES E..... 90 Bromfield Road, Tufts College, Mass.	Assistant Professor Mechanic Arts, Tufts College	1908
STEWART, JOHN L..... 678 Ostrum St., So. Bethlehem, Pa.	Professor of Economics and History, Lehigh University	1903
STEWART, LOUIS B..... Toronto, Ontario.	Professor of Surveying and Geodesy, Faculty of Applied Science and En- gineering, Toronto University.....	1897
STEWART, O. M..... 807 Virginia Ave., Columbia, Mo.	Professor of Physics, University of Missouri	1909
STOEK, HARRY H..... Urbana, Ill.	Professor of Mining Engineering, University of Illinois.....	1907
STONE, CHARLES A..... 147 Milk St., Boston, Mass.	Member of the Firm of Stone and Webster, Consulting Engineers.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
STONE, DON O..... 607 Houston St., Manhattan, Kan.	Assistant in Civil Engineering, Kansas State Agricultural College..	1909
STONE, E. ALBERT..... Fredericton, N. B.	Dean of Engineering School and Pro- fessor of Civil Engineering, Univer- sity of New Brunswick.....	1907
STORM, EDWIN R..... 160 Fifth Ave., New York, N. Y.	Architect	1908
STOUT, OSCAR V. P..... Lincoln, Neb.	Head Professor of Civil Engineering, University of Nebraska.....	1894
STOBEL, CHARLES LOUIS... 1744 Monadnock Block, Chicago, Ill.	Consulting Engineer	1909
STRONG, FRANK	Chancellor, University of Kansas.....	1907
STUBBS, JOSEPH E..... Reno, Nev.	President, University of Nevada.....	1897
SVENSEN, CARL L..... 46 Hillsdale Road, Tufts College, Mass.	Instructor in Mechanical Engineering, Tufts College	1909
SWAIN, GEORGE F..... Cambridge, Mass.	Professor of Civil Engineering, Gradu- ate School of Applied Science, Har- vard University	1893
SWETT, GEORGE W..... 17 Gray St., Cambridge, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technol- ogy	1907
SWIFT, WALTER	Secretary, Department of Applied Science, University of Sheffield.....	1902
TALBOT, ARTHUR N..... Urbana, Ill.	Professor of Municipal and Sanitary Engineering, and in Charge of The- oretical and Applied Mechanics, Uni- versity of Illinois.....	1893
TALBOT, HENRY P..... Boston, Mass.	Professor of Inorganic and Analytical Chemistry, Massachusetts Institute of Technology	1903
TANNATT, EBEN TAPPAN... 516 Empire State Bldg., Spokane, Wash.	Civil and Consulting Engineer.....	1907
TAYLOR, SAMUEL NEWTON.. 3422 Evans Place (Clifton), Cincinnati, Ohio.	Professor in Electrical Engineering, University of Cincinnati.....	1908

MEMBERS.

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NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
TAYLOR, THOMAS U..... Austin, Tex.	Professor of Civil Engineering, University of Texas.....	1902
TELLEN, J. MARTIN..... Cleveland, Ohio.	Assistant Professor of English, Case School of Applied Science.....	1908
THACH, CHARLES C..... Auburn, Ala.	President, Alabama Polytechnic Insti- tute	1905
THALER, JOSEPH A..... Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts	1901
THOMAS, ALBERT L..... Auburn, Ala.	Instructor in Machine Work and Me- chanical Drawing, Alabama Poly- technic Institute	1907
THOMAS, CARL C..... 633 N. Francis St., Madison, Wis.	Professor of Steam and Gas Engineer- ing, University of Wisconsin.....	1908
THOMAS, CHARLES FRANK.. 1486 E. 118th St., Cleveland, Ohio.	Instructor in Mathematics, Case School of Applied Science.....	1909
THOMAS, CHARLES W..... New York, N. Y.	Mechanical Department, Columbia University	1904
THOMAS, EVAN	Assistant Professor of Mathematics, Engineering Department, University of Vermont	1908
THOMAS, ROBERT G..... Charleston, S. C.	Professor of Mathematics and Engi- neering, South Carolina Military Academy	1894
THOMPSON, G. SAXTON..... 689 Second Ave., Troy, N. Y.	Assistant in Department of Mechanics, Rensselaer Polytechnic Institute....	1907
THOMPSON, F. F..... 91 Bayard St., New Brunswick, N. J.	Professor of Electrical Engineering, Rutgers College	1909
THORKELOSON, HALSTEN J... 1526 West Washington, Madison, Wis.	Associate Professor of Steam Engi- neering, College of Engineering, University of Wisconsin.....	1909
THORNBURG, CHARLES L.... South Bethlehem, Pa.	Professor of Mathematics and Astron- omy, Lehigh University.....	1894
THORPE, JOHN C..... 407 East Main St., Urbana, Ill.	Assistant Professor of Steam Engi- neering, University of Illinois.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
TIBBETS, FREDERICK H..... University of California, Berkeley, Cal.	Assistant Professor of Civil Engineer- ing, University of California.....	1908
TIMBIE, WILLIAM H..... Brooklyn, N. Y.	Instructor in Physics, Pratt Institute	1908
TITSWORTH, ALFRED A..... 590 George St., New Brunswick, N. J.	Professor of Civil Engineering, Rutgers College	1896
TOUCEDA, ENRIQUE A..... B'way cor. Thatcher St., Albany, N. Y.	Professor of Metallurgy, Rensselaer Polytechnic Institute, Troy, N. Y....	1907
TOWLE, WILLIAM MASON... 27 Main St., Potsdam, N. Y.	Superintendent of Shops, Clarkson School of Technology.....	1895
TOWNSEND, EDGAR J..... 510 John St., Champaign, Ill.	Professor of Mathematics, Dean of the College of Science, University of Illi- nois	1906
TRACY, JOHN C..... 345 Winthrop Ave., New Haven, Conn.	Assistant Professor of Structural En- gineering, Sheffield Scientific School, Yale University	1907
TRASK, BIRNEY E..... Burgh Street, Granville, Ohio.	Professor of Civil Engineering, Denison University	1907
TURNBAURE, FREDERICK E.. Madison, Wis.	Dean of the College of Engineering, University of Wisconsin.....	1894
TURNER DANIEL L..... 220 West 107th St., New York, N. Y.	General Inspector of Stations, Public Service Commission for the First District, New York City.....	1898
TURNER, WILLIAM P..... Lafayette, Ind.	Professor of Practical Mechanics, Purdue University	1900
TURBILL, SHERMAN M..... 1924 Waveland Ave., Chicago, Ill.	Structural Engineer	1903
TYLER, HARRY W..... 491 Boylston St., Boston, Mass.	Professor of Mathematics, Massachu- setts Institute of Technology.....	1894
ULBRICHT, T. CABLILE..... Brooklyn, N. Y.	Assistant Instructor, Department of Applied Mechanics, Pratt Institute..	1909
VAN HISE, CHARLES R..... Madison, Wis.	President, University of Wisconsin...	1904
VAN NESS, L. G..... 48 North Second St., Memphis, Tenn.	Secretary, Merchants' Power Co.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
VAN ORNUM, JOHN L..... St. Louis, Mo.	Professor of Civil Engineering, Washington University	1895
VAN ZANDT, J. GODSPEED 729 Harvard Boulevard, Los Angeles, Cal.	Associate Professor of Civil Engineer- ing, University of Southern Cali- fornia	1909
*VEDDER, HERMAN K..... East Lansing, Mich.	Professor of Civil Engineering, Mich- igan Agricultural College.....	1894
VON VOIGTLANDER, OSCAR F. 317½ Seward Place, Schenectady, N. Y.	Instructor in Civil Engineering, Union College	1908
VOSE, FRED HALE..... 10521 Lee Ave., Cleveland, Ohio.	Assistant Professor of Mechanical En- gineering, Case School of Applied Science	1907
*VOSSKUEHLER, JOSEPH H.. Madison, Wis.	Assistant Professor of Machine De- sign, University of Wisconsin.....	1902
VOTEY, J. WILLIAM..... Burlington, Vt.	Professor of Civil Engineering and Dean of Engineering Department, University of Vermont.....	1902
WADDELL, J. A. L..... Orear-Leslie Building, Kansas City, Mo.	Consulting Bridge Engineer, Waddell and Harrington	1893
WADSWORTH, JOEL E..... 22 Morsemere Place, Yonkers, N. Y.	Resident Engineer, American Bridge Co.	1895
WADSWORTH, M. EDWARD... Pittsburg, Pa.	Dean, School of Mines, and Professor of Mining Geology, University of Pittsburg	1895
WAIT, JOHN CASSAN..... Jesup Ave. & 172d St., The Bronx, New York, N. Y.	Attorney-at-Law, Wait & Foster, 38 Park Row	1907
WALDO, CLARENCE A..... St. Louis, Mo.	Professor of Mathematics, Washington University	1897
WALKER, ELTON D..... State College, Pa.	Professor of Hydraulic and Sanitary Engineering, The Pennsylvania State College	1895
WALKER, P. F..... 1301 Ohio St., Lawrence, Kans.	Professor of Mechanical Engineering and Director of Fowler Shops, Uni- versity of Kansas.....	1907
WARD, KENNETH B..... Columbus, Ohio.	Assistant in Civil Engineering, Ohio State University.....	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WATERMAN, EARLE L..... P. O. Box 502, State College, Pa.	Instructor in Civil Engineering, The Pennsylvania State College.....	1907
WEAVER, WILLIAM D..... West Englewood, N. J.	Editor, <i>Electrical World</i>	1909
WEBB, J. BURKITT..... Hoboken, N. J.	Consulting Engineer in Mathematics, Mechanics and Physics.....	1906
WEBBER, ROY I..... State College, Pa.	Associate Professor of Structural En- gineering, The Pennsylvania State College	1907
WEBSTER, EDWIN S..... 147 Milk St., Boston, Mass.	Member of the Firm of Stone and Webster	1907
WENDT, WYLIE B..... East Lansing, Mich.	Instructor in Civil Engineering, Michigan Agricultural College.....	1908
WENDELL, GEORGE V..... 400 West 118th St., New York, N. Y.	Professor of Physics, Stevens Institute of Technology....	1900
WESTCOTT, ARTHUR L..... 1402 Windsor St., Columbia, Mo.	Assistant Professor of Experimental Engineering, University of Missouri.	1908
WHEELER, EARL The Benedict, 1810 1st St., N. W., Washington, D. C.	Director, Electrical and Mechanical Engineering Department, Engineer- ing School, United States Army....	1907
WHEELER, LYNDE P..... 124 Linden St., New Haven, Conn.	Assistant Professor of Physics, Shef- field Scientific School, Yale Univer- sity	1908
WHIPPLE, GEORGE C..... 103 Park Ave., New York, N. Y.	Consulting Engineer, Firm of Hazen and Whipple	1896
WHITE, JAMES M..... Champaign, Ill.	Professor of Architectural Engineer- ing and Supervising Architect, Uni- versity of Illinois.....	1900
WHITEMORE, HERBERT L... Laboratory of Applied Mechanics, Urbana, Ill.	Associate in Applied Mechanics, University of Illinois.....	1909
WILEY, WILLIAM O..... 43 and 45 E. 19th St., New York, N. Y.	Publisher of Scientific Books, Secre- tary, John Wiley and Sons.....	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WILLARD, ARTHUR CUTTS.. 2204 Decatur Place, N.W., Washington, D. C.	Heating and Ventilating Engineer, Office of the Quartermaster General, Washington, D. C.....	1907
WILLIAMS, CLERMONT C.... 1133 Pleasant St., Boulder, Colo.	Acting Professor of Civil Engineering, University of Colorado.....	1909
WILLIAMS, FRANK B..... Worcester, Mass.	Professor of Mathematics, Clark College	1901
WILLIAMS, GARDNER S..... 1503 Washtenaw Ave., Ann Arbor, Mich.	Professor of Civil, Hydraulic and Sanitary Engineering, University of Michigan	1907
WILLIAMS, JOSEPH D..... Box 66, Fort Plain, N. Y.	Leveler, Department of State Engi- neer and Surveyor, Section No. 3, Erie Canal	1907
WILLIAMS, SYLVESTER N.... Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
WILLISTON, ARTHUR L..... 15 Berkeley St., Cambridge, Mass.	Director, Wentworth Institute, Bos- ton, Mass.	1897
WILMORE, JOHN J..... Auburn, Ala.	Dean, School of Engineering, and Pro- fessor of Mechanical Engineering, Alabama Polytechnic Institute.....	1894
*WILSON, ALEXANDER M.... 326 Harrison Ave., Lexington, Ky.	Professor of Electrical Engineering, State University of Kentucky.....	1907
WILSON, BIRTON N..... 241 College Ave., Fayetteville, Ark.	Professor of Mechanical Engineering, and Superintendent of Mechanic Arts, University of Arkansas.....	1907
WILSON, DELONZA TATE.... Cleveland, Ohio.	Assistant Professor of Mathematics and Astronomy, Case School of Ap- plied Science	1907
WILSON, VICTOR T..... East Lansing, Mich.	Professor of Drawing and Design, Michigan Agricultural College.....	1906
WILSON, WINTER L..... Bethlehem, Pa.	Professor of Railroad Engineering, Lehigh University	1909
WITHROW, JAMES R..... Columbus, Ohio.	Associate Professor of Chemistry, Ohio State University.....	1907
WOOD, ARTHUR J..... State College, Pa.	Associate Professor of Experimental Engineering, The Pennsylvania State College	1898

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WOODBIDGE, S. HOMER.... Boston, Mass.	Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology	1904
WOODWARD, CALVIN M.... St. Louis, Mo.	Professor of Mathematics and Applied Mechanics and Dean of the School of Engineering and Architecture, Washington University	1894
WOODWARD, ROBERT S..... 1513 Sixteenth St., Washington, D. C.	President, Carnegie Institution of Washington, Washington, D. C.....	1894
*WBENTMORE, CLARENCE G. 933 Forest Ave., Ann Arbor, Mich.	Assistant Professor of Civil Engineering, University of Michigan.....	1904
WRIGHT, ARTHUR S..... 1669 East 115th St., Cleveland, Ohio.	Professor of Modern Languages, Case School of Applied Science.....	1907
YERZLEY, WILLIAM ALFRED. 14 Garden St., Potsdam, N. Y.		1907
YOUNG, CLINTON M..... 407 W. Hancock St., Lawrence, Kan.	Associate Professor of Mining Engineering, University of Kansas.....	1907
YOUNG, DANIEL A..... R. F. D. No. 6, Schenectady, N. Y.	Leveler, State Water Supply Department, Lyons Block, Albany, N. Y...	1907
YOUNG, GILBERT A..... 409 University Ave., West Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University.....	1908
ZELENY, ANTHONY 321 Church St., S. E., Minneapolis, Minn.	Professor of Physics, University of Minnesota.....	1907
ZIMMERMAN, OLIVER B.... La Porte, Ind.	Mechanical Engineer and Chief Draftsman, M. Rumely Co.....	1902
ZIWET, ALEXANDER Ann Arbor, Mich.	Professor of Mathematics, University of Michigan.....	1897

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Names in italics are those of persons not engaged in teaching.

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- Brazil.**—Porto Alegre: J. Luderitz.
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Arizona	1	Minnesota	20	Tennessee	6
Arkansas	5	Mississippi	4	Texas	10
California	11	Missouri	27	Utah	6
Colorado	12	Montana	2	Vermont	6
Connecticut	14	Nebraska	6	Virginia	4
Delaware	2	Nevada	3	Washington	12
District of Columbia	8	New Hampshire..	5	West Virginia....	5
Florida	2	New Jersey.....	29	Wisconsin	27
Georgia	1	New Mexico	1	Australia	2
Idaho	2	New York	100	Brazil	1
Illinois	57	North Carolina...	5	Canada	9
Indiana	23	North Dakota....	5	China	3
Iowa	16	Ohio	53	England	2
Kansas	15	Oklahoma	3	Hungary	1
Kentucky	4	Oregon	3	Italy	1
Louisiana	6	Pennsylvania	66	Mexico	1
Maine	3	Rhode Island.....	7	Philippine Islands	2
Maryland	1	South Carolina ..	2	Total	747
Massachusetts ...	78				

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	Members		
	1907	1908	1909
Massachusetts Institute of Technology	21	37	34
University of Illinois	18	24	26
University of Wisconsin	16	18	24
Ohio State University	20	22	22
University of Minnesota	14	20	20
Purdue University	16	17	18
Pratt Institute	5	15	17
The Pennsylvania State College	10	16	16
Stevens Institute of Technology	6	12	14
Case School of Applied Science	11	14	14
Yale University	2	11	13
Worcester Polytechnic Institute	11	11	13
Cornell University	10	11	11
Columbia University	12	10	11
University of Michigan	9	10	11
Michigan Agricultural College	3	10	11
Harvard University	6	7	11
Iowa State College	6	7	10
University of Kansas	2	10	10
Lehigh University	6	7	10
University of Missouri	5	8	10
Union University	3	6	9
Tuft's College	3	6	9
Armour Institute of Technology	5	8	7
Carnegie Technical Schools	4	6	7
Washington University	3	6	7
University of Washington	7	7	7
Brown University	6	8	7
Agricultural and Mechanical College of Texas	5	5	6
University of Cincinnati	5	5	6
Alabama Polytechnic Institute	4	6	6
University of Nebraska	6	6	6
University of Vermont	4	6	6
Michigan College of Mines	9	9	6
University of Pennsylvania	3	5	6
Rutgers College	1	3	5
University of Arkansas	3	3	5
Colorado State Agricultural College	2	4	5
University of West Virginia	4	4	5
Clarkson School of Technology	3	5	5

	Members		
	1907	1908	1909
University of Colorado	5	6	5
State University of Iowa	6	6	5
Drexel Institute	2	2	5
Kansas State Agricultural College	0	1	5
State University of Kentucky	1	3	4
University of California	3	3	4
New York University	1	3	4
Polytechnic Institute of Brooklyn	4	4	4
Tulane University	4	4	4
Cooper Union for the Advancement of Science	1	5	4
Northwestern University	1	2	4
James Millikin University	1	1	3
George Washington University	2	2	3
Nevada State University	2	2	3
South Dakota Agricultural College	2	2	3
Lewis Institute	1	3	3
Rensselaer Polytechnic Institute	1	3	3
Thayer School of Civil Engineering of Dartmouth College	3	3	3
University of Mississippi	3	3	3
University of Tennessee	2	3	3
University of Texas	3	3	3
Leland Stanford Junior University	4	4	3
University of North Dakota	2	4	3
University of Utah	0	2	2
Rose Polytechnic Institute	3	3	2
Princeton University	1	1	2
Imperial Pei Yang University, Tientsin China	0	0	2
University of Southern California	0	0	2
Bradley Polytechnic Institute	2	2	2
Delaware College	1	2	2
International Correspondence Schools	2	2	2
Louisiana State University	1	2	2
New Hampshire College of Agriculture and Mechanic Arts	1	2	2
North Carolina College of Agriculture and Mechanic Arts	1	2	2
Toronto School of Applied Science	3	2	2
University of Florida	2	2	2
University of Maine	1	2	2
University of Toronto	0	2	2
Virginia Polytechnic Institute	1	2	2
Williamson Free School of Mechanical Trades	0	0	2
McGill University	3	3	2
Colorado School of Mines	3	3	1
Milwaukee School of Trades	0	1	1

	Members		
	1907	1908	1909
Alabama Girls' Industrial School	1	1	1
Bowdoin College	0	1	1
Brooklyn Manual Training High School	0	0	1
Bucknell University	1	1	1
Carnegie Institution	1	1	1
Clark College	0	1	1
Clemson College	1	1	1
Cleveland High School	0	1	1
Colorado College	1	1	1
Cornell College	1	1	1
Denison University	0	1	1
Dorchester High School	1	1	1
Franklin Union	0	1	1
Haverford College	1	1	1
Montana College of Agriculture and Mechanic Arts	1	2	1
University of Arizona	2	2	1
Imperial College of Science and Technology (England) ..	0	0	1
Imperial Polytechnic College, Shanghai, China	0	0	1
Instituto Technico Professional, Porto Alegue, Brazil ..	0	0	1
Kansas City High School	1	1	1
Lafayette College	1	1	1
Marquette University	0	0	1
Massachusetts Agricultural College	1	1	1
New Mexico College of Agriculture and Mechanic Arts ..	0	1	1
North Georgia Agricultural College	1	1	1
North Dakota Agricultural College.....	1	1	1
Nova Scotia Technical College	0	1	1
Ohio Northern University	0	1	1
Ohio Wesleyan University	0	1	1
Oklahoma School of Mines and Metallurgy	0	1	1
Oregon Agricultural College	0	1	1
Philadelphia Central Manual Training High School	1	1	1
St. Louis McKinley High School	1	1	1
South Carolina Military Academy	1	1	1
State School of Mines of Utah	1	1	1
Swarthmore College	0	1	1
Throop Polytechnic Institute	1	1	1
United States Engineering School	0	1	1
United States Naval Academy	0	0	1
University of Alabama	2	1	1
University College, Sheffield, England	1	1	1
University of Chicago	1	1	1
Cathedral College	0	0	1

INSTITUTIONS REPRESENTED.

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	Members		
	1907	1908	1909
Mississippi Agricultural College	0	0	1
Montana University	0	0	1
University of Idaho	0	2	1
University of Manitoba	1	1	1
University of Syracuse	1	1	1
University of Pittsburg	0	1	1
University of North Carolina	0	1	1
University of South Dakota	1	1	1
University of Sydney	1	1	1
University of New Brunswick	0	1	1
University of Oregon	0	1	1
Valparaiso University	0	0	1
Vanderbilt University	1	1	1
Virginia Military Institute	0	1	1
Washington and Lee University	1	1	1
Wentworth Institute	0	0	1
Western University of Pennsylvania	1	1	1
Whitman College	0	0	1

SUMMARY BY OCCUPATION.

Classification	Teachers			Practitioners		
	1907	1908	1909	1907	1908	1909
Architecture	3	4	5	0	0	0
Biology	2	2	1	0	0	0
Chemistry	8	12	10	2	2	1
Civil Engineering	102	130	160	34	36	22
Deans and Directors only	11	22	28	0	0	0
Drawing	16	27	42	0	0	0
Electrical Engineering	47	72	81	13	15	15
Journalists	0	0	0	9	11	15
Manual Training	4	4	4	0	0	0
Mathematics	38	56	63	2	1	1
Mechanical Engineering	81	112	117	18	19	27
Mechanics	15	23	25	0	0	0
Mining Engineering	14	20	28	6	6	4
Physics	24	38	36	0	0	0
Presidents	15	22	23	0	1	0
Shopwork	10	12	6	0	0	0
Trade-school	5	5	4	0	0	0
Unclassified	8	14	9	10	9	20
Professors who are also Deans ..	(40)	(41)	(54)			
Total	409	575	642	94	100	105

GENERAL SUMMARY.

DIFFERENT INSTITUTIONS REPRESENTED.

	1907	1908	1909
Colleges and Universities teaching Engineering			
Domestic	94	116	126
Foreign	5	5	9
Manual Training, High, Correspondence, and Trade			
Schools	17	19	9
Total Institutions	116	140	144
Teachers, and, in many cases, also practitioners ...	409	575	642
Practitioners, not teaching	94	100	105
Total Members	503	675	747

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS—Members of the Society shall be those persons who occupy or have occupied responsible positions in the work of engineering instruction, together with engineering practitioners and other persons interested in engineering education.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Any Member not in arrears for dues may become a Life Member by paying Fifty Dollars into the Treasury of the Society at one time.

The name of each candidate for membership shall be proposed in writing to the Council by two members by whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting, a vote of three-fourths of those present being required to elect; or, during the period between annual meetings, an affirmative letter ballot of three-fourths of those members of the Council whose vote reaches the Secretary within one month from the time of sending out the name of the candidate shall elect. Such letter ballot elections shall be credited to the previous annual meeting and dues will date from that time.

3. OFFICERS—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year, or until their successors have been elected and have qualified. The Officers shall be elected by ballot of the Society at the annual meeting.

4. COUNCIL—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the Past Presidents of the Society shall be members of the Council *ex-officiis*.

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates *ad interim*, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

The President of the Society shall be Chairman of the Council, and the Secretary of the Society shall be Secretary of the Council and shall keep the minutes of its meetings and an accurate record of all its actions.

When votes taken by letter ballot of the Council shall be required, all votes which reach the Secretary within one month from the time of sending out the ballots shall be counted, but votes reaching the Secretary later than the time here specified shall not be counted.

5. NOMINATING COMMITTEE—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES—The admission fee, which shall also include the first year's dues, shall be Three Dollars and Fifty Cents (\$3.50), and the annual dues thereafter Three Dollars

and Fifty Cents (\$3.50), payable at the time of the annual meeting. The fiscal year shall end with the opening of the first General Session of the Annual Meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who has been in arrears more than two years and duly notified by the Secretary, shall be dropped from the roll, until such arrearages are paid.

7. MEETINGS—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the Nation Engineering Societies, or otherwise as the Council may determine.

8. PUBLICATIONS—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. AMENDMENTS—This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the Society provided the Amendment shall have been approved by a two-thirds vote of the Council taken by letter ballot.

BY-LAWS OF THE SOCIETY AND RULES GOVERNING THE COUNCIL.

First. The Officers of the Society shall constitute a Committee to arrange for the annual meeting and to prepare a program for the same.

Second. The President, the Secretary and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of appropriations for Committees and other purposes, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

Third. Expenditures of money may be made only in accordance with a definite appropriation or direct vote of the Executive Committee and bills shall not be paid by the Treasurer until they have been approved by all members of the Executive Committee.

Fourth. Reading of papers shall be limited to fifteen minutes each or to such other time as may be designated by the Program Committee, and abstracts of papers of about three hundred words shall be printed when practicable, and distributed in advance to the members.

Fifth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

Sixth. The President, the Secretary and the retiring Secretary shall constitute a Publication Committee, of which the Secretary shall be Chairman, to edit and have charge of the publication of the Proceedings of the Society. If at any time there be no retiring Secretary the retiring President shall be a member of this Committee.

Seventh. Additions or amendments may be made to these By-Laws on recommendation of the Council by a two-thirds affirmative vote at any regular meeting of the Society.

PUBLICATIONS.

The publications of the Society can be obtained from the Secretary. The current issues are distributed gratuitously to members in good standing. The price of the bound volumes of the Proceedings is \$2.50 to non-members, \$2.00 to public libraries, and \$1.50 to members for their own libraries.

Reprints of papers may be ordered when the paper is in type form, and either with or without covers, at a price depending upon the number of pages and copies desired.

PROCEEDINGS.

NEW YORK MEETING.

JUNE 24 TO JUNE 26, 1909.

The Seventeenth Annual Meeting of the Society for the Promotion of Engineering Education was held in New York City during the week of June 21 to June 27, 1909, the various sessions being held at Earl Hall, Columbia University, New York City, Pratt Institute, Brooklyn, and the United Engineering Societies Building, 29 West 39th Street, New York City.

THURSDAY, JUNE 24.

EARL HALL, COLUMBIA UNIVERSITY.

Afternoon Session.

The meeting was called to order on Thursday afternoon, June 24, with President Frederick E. Turneaure, dean of the College of Engineering, University of Wisconsin, in the Chair. The meeting was opened by an address of welcome from Mr. William Barclay Parsons, a trustee of Columbia University. Mr. Parsons represented President Nicholas Murray Butler, who was unable to be present. Mr. Parsons' address was responded to by President Turneaure.

The report of the Treasurer was read and accepted. At the request of the Treasurer, Mr. William O. Wiley, the report was referred to an auditing committee. Professors Hibbard, Maurer and Constant were appointed upon this committee. Next the report of the Secretary, Professor Ar-

thur L. Williston, was read and accepted. In putting the motion the Chairman called attention to the very gratifying growth in numbers indicated by the report.

The report of the Committee on Technical Books for Libraries was presented in printed form. The discussion brought out the desirability of a careful revision of the report, and the following motions were carried:

(Motion 1) "That the report be referred back to the committee for revision and correction, and that printed copies be distributed among the members of the Society with the request that they send suggestions for revision or correction to the committee"; and (Motion 2) "That the committee be given power to enlarge its membership as may seem wise to the committee." The discussion on these motions brought out several practical suggestions, as follows: (1) That the suggestions of practical librarians should be secured; (2) That the work should be subdivided, with specialists in each of the subdivisions on the committee; (3) That the thanks of the Society are due the committee for the large amount of work already done; (4) That any radical revision of the report is impracticable in the limited time available.

The next topic discussed was the teaching of mathematics to students of engineering. Professor E. V. Huntington described the work accomplished by a committee appointed by several societies in Chicago in December, 1907. Following the discussion of Professor Huntington's report, the Secretary read a long list of names of applicants for admission to membership. The Secretary was instructed to cast a ballot for all of the names read.

Evening Session.

President Turneure read an address entitled "Present Tendencies in Technical Education." This was followed by a paper on "Highway Engineering," by Mr. L. W. Page, Director of the Office of Public Roads, United States Department of Agriculture. The discussion indicated the considerable interest taken by the Society in highway improvement.

FRIDAY, JUNE 25.

PRATT INSTITUTE.

Morning Session.

The Society was welcomed to Pratt Institute by Mr. Fred-eric B. Pratt, executive officer of the institute. Mr. Pratt spoke on behalf of the trustees and explained the underlying principles of this important foundation. Mr. Charles B. Going, editor of the *Engineering Magazine*, then read a paper on the "Relation of Engineering Education to Industries." Following this was a paper by Mr. F. W. Taylor, past-president of the American Society of Mechanical Engineers, entitled, "Why Employers Dislike College Graduates." These papers contained radical suggestions regarding engineering education and provoked animated discussion.

UNITED ENGINEERING SOCIETIES BUILDING.

Afternoon Session.

Professor Louis E. Reber, director of the University Extension Department, University of Wisconsin, read a paper on "University Extension Work in Wisconsin." Professor D. C. Jackson, chairman of the Joint Committee on Engineering Education, presented an informal report of the work of the committee to date. He promised a full report at the next annual meeting. Following were three papers on the subject of five- and six-year engineering courses. These were "The Length of an Engineering Course," by Professor Charles Derleth; "Five and Six-year Courses in Engineering Schools," by Professor Robert Fletcher; "The Five-year Courses," by Professor Wm. T. Magruder. These papers were discussed at great length. Professor Hugo Diemer then read a paper on "Employers' Requirements: What Qualifications do Employers Most Desire from Graduates in a Course of Mechanical Engineering?"

The President then announced as the Nominating Committee, Professors Swain, Eddy, Allen, Merriman and Fletcher.

SATURDAY, JUNE 26, 1909.

EARL HALL, COLUMBIA UNIVERSITY.

Morning Session.

The nominating committee presented the following report and the Secretary was instructed to cast one ballot for the Society for the names as read.

For President: Professor H. S. Munroe, Columbia University.

For Vice-Presidents: Professor A. N. Talbot, University of Illinois, and Professor A. L. Williston, Pratt Institute.

For Secretary: Professor H. H. Norris, Cornell University.

For Treasurer: Mr. William O. Wiley, New York.

For members of Council, term to expire 1912: Professor F. H. Constant, University of Minnesota; Dean F. A. Goetze, Columbia University; Professor H. Wade Hibbard, University of Missouri; Dean John H. Leete, Carnegie Technical Schools; Professor E. R. Maurer, University of Wisconsin; Professor John C. Ostrup, Stevens Institute; Professor Charles R. Richards, Cooper Union.

The committee appointed to audit the report of the Treasurer reported that they had gone carefully over the books, accounts and vouchers and had found them correct and satisfactory. The report of the committee was accepted. The Secretary then read a long list of names of applicants for membership which had been duly recommended by the Council. The list was approved by the Society. The Secretary reported the registration at the convention as 103. He stated that the attendance of 75 at the Cleveland meeting, was the record up to 1907. The discussion of five-year courses was then continued. Dean M. E. Cooley then presented a paper on "Careers of the Graduates of the University of Michigan," illustrating his conclusions by tables and diagrams and appending a list of quotations from letters received from graduates.

President-elect Henry S. Munroe was next escorted to the platform by a special committee, and in the following words accepted the responsibility of his new position:

“ Mr. President and Members: The action of your Nominating Committee, and my election by the Society, comes to me as a complete surprise, and I can only say that I appreciate the honor very greatly. I shall do what is in my power to advance the best interests of the Society. I have been engaged in the promotion of engineering education of one kind for nearly one third of a century, for more than half of my life, and naturally I take great interest in the main object of the Society. I feel that not only has the Society done good work in the past, as is evidenced by the long row of blue volumes that stand on one of the shelves in my bookcase, but that we are entering upon an even greater field of usefulness.

“The discussion that has been started in the last day or two in regard to the length of the courses, and the work that is being done by a special committee upon the details of an engineering course, promises important results. We have, at Columbia, at different times, been engaged in investigations of that character with accompanying revisions of courses. This has occurred in all branches of engineering. Speaking as one who has worked in that field, I know that a society such as this will certainly accomplish something. I am proud to be able to take part in these labors during the coming year.”

The Secretary then made the suggestion that the report of the Committee on Entrance Requirements presented by the Chairman, Professor J. J. Flather, be printed as an advance of a paper to come up for discussion and criticism or adoption at the next annual meeting. A motion that Professor Williston's suggestions be adopted was passed.

The program of the annual meeting was concluded by the reading of the following papers: “ The Regulations Governing Examinations,” by Professor William K. Hatt (read in full), “The Requisite Qualifications of an Engineering College In-

structor," by Mr. Oliver B. Zimmerman, and "A Summer School in Surveying," by Professor Charles Derleth, Jr. (the latter two read by title).

In conclusion the Committee on Resolutions reported the following which was adopted and the convention adjourned.

RESOLUTION.

The Society desires to place on record an appreciation of the many courtesies and facilities which have been extended at this meeting and which have contributed so largely to its success, and to the convenience, entertainment, and enjoyment of the members and guests of the Society, therefore

Be it Resolved, that the thanks of the Society be tendered to Columbia University and to Pratt Institute, for providing places of meeting and for hospitable entertainment, including the use of the dormitories of Columbia University; that thanks be also tendered to the United Engineering Societies, and to the Engineers' Club for the use of their buildings, and to the automobile companies, for the automobile ride; and that most hearty thanks be tendered to the Colleges of New York, and to the friends who have so hospitably contributed to the pleasure and enjoyment of members and of the ladies accompanying them and likewise to Mrs. Goetze for her part in the entertainment of the ladies.

Signed,

A. N. TALBOT,
F. P. SPALDING,
C. F. ALLEN,
Committee.

SECRETARY'S REPORT, 1908-1909.

To the Society for the Promotion of Engineering Education:

Your Secretary is glad to report that the affairs of the Society are in a most prosperous and flourishing condition. The membership at the close of the last annual convention was

675. During the year 97 new applications have been received and favorably acted upon. During the year also, 12 members resigned and but one death has been reported, making a total loss of but 13 members. The net gain, therefore, is 84, which makes the total membership of the Society at the present time 759.

The growth of the Society during the past ten years is set forth in the following table:

TABLE SHOWING GROWTH OF MEMBERSHIP.

Year.	Membership.	Gain.	Year.	Membership.	Gain.
1900	249	11	1905	379	54
1901	260	11	1906	415	36
1902	253	7 (loss)	1907	503	88
1903	273	20	1908	675	172
1904	325	52	1909	759	84

The resignations received were as follows: R. B. Brinsmade, C. R. Burger, L. M. Haupt, J. V. Hazen, C. F. Mabery, L. C. Monin, R. E. Myers, E. H. Powell, H. W. Reynolds, L. Rouillion, C. E. Sherman, and C. G. Wrentmore.

Thomas Gray, for many years Professor of Dynamic Engineering at Rose Polytechnic Institute, Terre Haute, Ind., for fourteen years a member of this Society, one of its past vice-presidents, and twice a member of its Council, died on December 19, 1908.

In conclusion the Secretary wishes to thank the officers of the Society and the entire membership for the help that they have given him in carrying on the routine work of the office and in the preparation for the meetings; and also for their cordial coöperation in extending the influence of the Society by bringing the many advantages of membership to the favorable attention of those outside its immediate ranks.

Respectfully submitted.

ARTHUR L. WILLISTON,
Secretary.

TREASURER'S REPORT, 1908-1909.

To the Society for the Promotion of Engineering Education:

The Treasurer would respectfully report to the Society the condition of its finances, as follows:

SUMMARY OF RECEIPTS.

June 15, 1908, Cash balance on hand.....	\$ 675.69
June 15, 1908, to June 21, 1909,	
Received for 1908-9 dues.....	2,023.58
Received for dues prior to 1908-9.....	192.00
Received from sale of volumes of "Proceedings".....	260.75
Received for author's reprints.....	129.24
Received interest at bank, July 1, 1908, January 8, 1909...	15.89
Total receipts	<u>\$3,297.15</u>

SUMMARY OF EXPENDITURES.

Programs and badges for Detroit meeting.....	\$ 52.25
Reporting Detroit meeting.....	76.00
Expenses of Treasurer for stationery, postage, etc. (including clerical assistance).....	165.77
Expenses of Retiring Secretary, Professor Magruder.....	82.44
Expenses of Secretary for printing, postage and clerical assistance (includes expenses campaign for new members).....	832.50
Editorial work, Volume XIV.....	100.00
Secretary's honorarium (two years).....	500.00
The New Era Printing Company,	
For Volume XV. (\$1,000 paid last year).....	136.16
For lists of members, author's reprints, expressage, etc....	507.14
Sterling Engraving Company, cuts for Volume XV.....	25.99
Cash on hand June 21, 1909.....	818.90
	<u>\$3,297.15</u>

ASSETS.

June 21, 1909, Cash on hand.....	\$ 818.90
Due from members and non-members.....	521.53
	<u>\$1,340.43</u>

LIABILITIES.

June 21, 1909, no unpaid bills on hand, as bills for printing Volume XVI. of "Proceedings" have not yet been submitted.

The cost of the "Proceedings," Volume XVI., will be \$795.92. The authors' corrections amount to \$9 on the entire volume.

The cost of the reprints for the New York meeting is \$200.

The total amount due the society is \$521.53, as compared with \$512.85 last year. There are 64 members one year in arrears; 23, two years; 6, three years; 3, four years; and 3, five years. The total arrearage in membership-years is $(64 \times 1) + (23 \times 2) + (6 \times 3) + (3 \times 4) + (3 \times 5) = 155$. This corresponds to 124 last year. The number in arrears one year is smaller, but the number in arrears two years is larger than a year ago.

Respectfully submitted,
WILLIAM O. WILEY,
Treasurer.

The following applicants were admitted to the Society between July 1, 1908, and July 1, 1909.

Elected by letter ballot March 16, 1909; W. R. Bryans, L. E. Conrad, L. N. Daniels, W. Easby, Jr., P. N. Evans, E. E. King, O. M. Leland, C. L. McMaster, J. A. Pratt, J. I. Stewart, O. M. Stewart, F. H. Tibbetts, W. L. Wilson (13).

Elected by the Society at the New York meeting: W. H. Adams, P. R. Alger, G. F. Ashley, H. N. Benkert, H. S. Bitting, A. Boyd, W. H. Bristol, H. B. Brown, H. D. Burghardt, J. W. Burley, C. A. Cadwell, J. P. Calderwood, J. A. C. Callan, C. E. Comstock, R. T. Craig, W. B. Creagmile, G. Crisson, N. P. Curtis, James C. Davis, John C. Davis, F. H. Tibbetts, W. E. Dickinson, C. E. Downton, E. V. Dunstan, S. C. Earle, T. J. Eyre, H. B. Fine, V. R. Fleming, M. M. Foss, L. K. Frankel, E. H. Freeman, A. H. Gill, M. R. Hammer, C. H. Harper, C. N. Haskins, A. W. Hendrick, H. H. Higbie, E. C. Holden, E. G. Hooper, L. W. Irish, C. M. Jansky, A. R. Johnson, V. Karapetoff, O. A. Kenyon, V. P. Knott, J. P. Kottcamp, F. A. Laws, C. W. Lawrence, T. K. Lewis, R. C. MacLaurin, L. S. Marks, T. C. Martin, W. J. McAuliffe, J. R. McConnell, W. E. McCourt, C. Mehely, A. C. Mehrtens, R. Meiklejohn, H. C. Mitchell, A. H. Nelson, H. Pender, A. A. Potter, F. R. Pratt, G. D. Pratt, F. O. Price, E. Querbach,

D. W. Richards, E. F. Roeber, C. H. Sanford, F. H. Sexton, S. S. Seyfert, J. B. Shaw, E. M. Shealy, A. G. Smith, L. B. Smith, C. L. Strobel, C. L. Svensen, S. N. Taylor, C. F. Thomas, F. F. Thompson, T. C. Ulbricht, J. G. VanZandt, W. D. Weaver, H. L. Whittemore (84).

SOCIAL REUNIONS.

During the convention there were planned, thanks to the generosity and public spirit of the local colleges and educational institutions and a number of the friends of the Society, a number of social gatherings at which the members of the Society who attended the convention had the most delightful opportunity of meeting their friends in an informal way, of renewing old acquaintances and of making many new ones.

The first of these was an informal reception or "smoker" with refreshments, tendered to the members of the Society by the Trustees of Columbia University on the Columbia campus between Earl Hall and the Faculty Club, which was given on Thursday evening, June 24th, immediately following the session at which the President's address was delivered. The grounds on this portion of the campus were beautifully decorated with Japanese lanterns, and tables were distributed under the trees around which groups of friends gathered to renew old associations.

RECEPTION AT PRATT INSTITUTE.

At the close of the session on Friday morning, June 25th, which was held at Pratt Institute, Brooklyn, the Trustees of Pratt Institute tendered the members of the Society an informal reception and luncheon on the first floor of the Chemistry Building as an appropriate and refreshing conclusion to an interesting visit through the shops and laboratories of the Institute.

After the luncheon, the members took the subway trains to

the Building of the United Engineering Society where the afternoon session was held.

BANQUET AND THEATRE PARTY.

The most formal and one of the most successful occasions of the social gatherings of the Society was the banquet for the members given in the main dining room of the Engineer's Club at which the chef and members of the House Committee of the club quite outdid themselves in their endeavor to show that teachers of engineering were most welcome guests at the club.

Immediately after the banquet, the members met the ladies who were attending the convention and who had been escorted downtown from a dinner party planned for them at Columbia by Mrs. Goetze. Together, they proceeded to the Roof Garden of the New York Theatre where a most enjoyable evening was spent. And then after the theatre, many proceeded for an informal gathering at the Hotel Astor, across the street, before the party dispersed for the evening.

Besides these welcome interruptions to the more serious work of the convention provided for the members of the Society and for which provision was made on the program, there was even a greater number of events planned for the entertainment of the ladies who attended the convention, which included among other things a trip down the harbor, an automobile ride, luncheon and a dinner party.

And still another feature of the New York convention which added much to the comfort and general enjoyment for a great many of the out-of-town members was the hospitality of Columbia University in throwing open one of its finest dormitories for the Society and putting the rooms at the disposal of members and their families without charge. Here everyone who applied was made comfortable and suites of two or three rooms were reserved for members who were attended by ladies. The opportunity thus offered for the informal life in

the dormitories on the Columbia Campus and the pleasure it afforded during the busy week of the convention will be well remembered as one of the things which contributed greatly to the social success of the meeting of 1909.

The above minutes are herewith respectfully submitted to the Society.

HENRY H. NORRIS,
Secretary.

ADDRESS OF WELCOME.

(ON BEHALF OF COLUMBIA UNIVERSITY.)

BY MR. WILLIAM BARCLAY PARSONS,
Trustee of the University.

Mr. President and Members of the Society: It is my very pleasant duty, on behalf of the president of this university and the board of trustees, to bid you all welcome. I assure you that I have but one regret, which is that the greeting could not have been extended to you by the president himself, because I know that nothing would have given him greater pleasure. In his absence you will permit me to add to my official greeting on behalf of the university, my own personal good wishes as a worker in the field of the profession, and as a graduate in engineering of this university. I am confident that I can promise that while you are here, that my good friend, Dean Goetze, will do all in his power to make you comfortable and happy. I sincerely hope that your deliberations will meet with the greatest success.

The objects of your Society to promote a betterment in engineering education are second in importance to none. The education of an engineer is probably more complex and difficult than the education of any other professional man. That education approaches perfection in direct ratio as you gentlemen are able successfully to mingle the seemingly irreconcilable factors of theory and practice; of science and art. I use the word seemingly advisedly, for it is probable that the devotees of art, for instance, would treat with scorn the idea that art is in any way connected with science. And yet art is only good when, in its last analysis, it obeys the canon of its own scientific criticism, and, certainly, practice can only be good when it is founded upon the most drastic theory.

But, Mr. President and gentlemen, it is not for me to tell professors about their own chosen work, but it is for me, as a

working member of the profession, to express to you the obligations of every man in the profession for the services that you and your colleagues are rendering to us all. I, therefore, acknowledge, on behalf of the profession, the great debt that we all owe you, and men like you, who are willing to put behind them the attractive excitement of work in the field; to forego also all the chances for the higher financial rewards of the profession; in order to devote their whole lives quietly in their class rooms that others may learn. In speaking of the profession at large, I also include myself. I am very glad to avail myself of this opportunity to publicly acknowledge that whatever measure of success I have attained in the profession is due entirely to those of your forerunners who gave me my education.

Gentlemen, you will allow me again to wish you, in your deliberations and in your conferences, every possible success; and to assure you that whatever we here at Columbia have is yours to command just as long as you want to stay. Whatever hospitality we can offer is offered gladly, because it is but a very small acknowledgment of the benefit that is bound to accrue to this University as a result of your meeting here.

Once more, gentlemen, on behalf of Columbia, I bid you all welcome; yea, I may say to each and every one of you personally, thrice welcome.

ADDRESS OF WELCOME.

(ON BEHALF OF PRATT INSTITUTE.)

BY MR. FREDERIC B. PRATT,

Executive Secretary, Pratt Institute.

Mr. President and Gentlemen:

Our trustees have asked me to extend to you in their behalf a very cordial welcome to Pratt Institute. It has seemed to them that your Society, more than most of the other engineering societies, would be interested in the problems we are trying to work out, because you are perhaps more interested in *education* than you are in *engineering*. I shall, therefore, take pleasure in telling you briefly of the early work of the Institute, of the idea for which it stands, and of the story of how it came into being.

The founder was a self-made man, brought up on a farm, but started early in life as a machinist. He was ambitious for an education, but found great difficulty in finding any place where he might study. All the schools were closed at night, which he felt to be a mistake, and he determined that, if he were ever in a position to provide for other boys the opportunities that he wanted and that were denied him, he would do it.

I think no one realized that this desire was in his mind, until along late in life he began to study the question of industrial education and tried to work out some practical plan for making it available for the young men and women who were anxiously looking for help and training to make them more skilled workers. The Institute was organized, therefore, to meet a very real, human need, which the founder understood through a personal experience.

A generation ago, industrial education was an experiment in this country. It had been established in Europe, but there

was very little of it here, other than manual training or engineering work. Mr. Pratt felt that there was, between the manual training on the one hand and the engineering on the other, the need for a type of work that might help large numbers of students who wanted to fit themselves to work along industrial lines. Manual training instruction was confined largely to the public and private schools and was not especially helpful in fitting a boy for industrial work. Engineering instruction, on the other hand, was too far removed from the possibilities of the ordinary boy who left school from thirteen to fifteen years of age and who was not prepared to meet the entrance requirements of the colleges. Such a boy needed a place where he could get the elements of technical training that would prepare him specifically for some form of skilled labor.

The Institute was started to do this work. It began in a small way with twelve pupils, one director, and one instructor. The director came to Mr. Pratt the morning that the school opened and said: "Mr. Pratt, I hope you won't be discouraged. I know you have put a lot of money into building, equipment, and endowment, and it is too bad not to have more students at the start." "That's all right," said the founder, "I would rather have twelve than fifty, for we know what to do with small numbers, and, if we do the absolutely square thing by these twelve, we shall have twenty-four next month, forty-eight, the next, and that's the *right* way to grow." It was not a discouragement to him, and, fortunately, it was not a discouragement to those who were identified with the work in those early days. In fact, I think of it as one of heaven's peculiar wonders that we had the advantage of having a small number of students to begin with. It kept us simple in our ideas and helped us to keep our attention on the pupil and his actual needs and possibilities.

And so, year after year, the work has gone on growing, as predicted by the founder, our students have increased in numbers, the work has increased in extent, and we have a constantly increasing opportunity for rendering a greater service. I have known a number of schools that have started from

private foundations, given by men who have had large means, with the hope that the schools should do what this school has done. Frankly, I think that they have made mistakes in trying to start "full-fledged" with the idea that such work could be created in a night. Now, as you know, school work is a growth. It cannot be developed by advertising, nor can it be created and spread over the country in a single day, like some newly-patented article. In school work the foundations must be laid broad and deep, and one must be very patient in looking for results.

It is true that the early years of our life here were full of experiment—we don't experiment as much now, though we are willing to change and do change to meet new conditions and as we get more light on our problems and as we discover better ways by experience—but our experiments were always an effort to find the best way to teach industrial subjects and the best way to meet the needs of students, and never an effort to find a new field of work. It seems to me that this holding to the original purpose of the founder has built up a confidence on the part of the public both in our integrity of purpose and in our perseverance in carrying out our ideas. The permanency of our plan has become one of the quiet, underlying influences of this place, and those who have come here have felt it and have naturally been modified by it.

But the founder had another idea than his plan to develop technical education of a secondary grade. He believed that all training, of whatever kind, should be human training. He recognized that each boy and each man is a human being and that the only way to get service from him is to treat him as a human being. He gave to us early the advice that became the motto of the institution: "Be true to your work and your work will be true to you." This idea of the work as the expression of character of the student has been a favorite one with us. We try to develop in our students character, integrity and the right spirit towards their work and towards their fellow men. That purpose is the founder's invaluable legacy to us.

As you know, many private institutions are organized in

such a way that they are too far removed from the man who starts them. The man gives the money and says "Go ahead, build your buildings and get somebody to direct your work and I will supply the funds." But too frequently the individual has left out of his work his own personality. Now, the founder of this institution put into it his own personality, which is worth more to us than our endowment and which we must keep in our work at any cost.

The Institute is organized in a rather peculiar way. As a member of the family, as one of the founder's sons, it was my good fortune to be asked, early in its history, to act as its executive secretary.

My personal training had not been along engineering or technical lines, and I rather questioned the wisdom of putting the management of an institution of this kind into the hands of a layman. Experience has shown, however, that, by protecting ourselves by the engagement of able instructors and strong men, leaders in their particular fields of work, we have been able to build up a stronger organization than we could have built by placing at the head of the work one individual, however strong he might have been intellectually or however well prepared from the scientific standpoint. We have developed a better form of organization and have secured greater freedom of action than have most schools. Such an organization has made possible great freedom for the directors of our various schools, and I hope that this liberty may always be given them. The trustees have kept in close touch with the directors, have been interested in their problems, and have helped them as far as they have been able to do so.

I wish that I could in some adequate way present to you the feeling that our trustees have towards this work, their intense loyalty to it and their deep personal interest in it. We find this same feeling towards the school on the part of our teachers and students. I do not speak with any degree of false pride, but with a sense of intense gratitude that what we have been trying to do is understood and appreciated by our own people.

In conclusion, gentlemen, I wish to extend to you once more a most cordial welcome to this place.

RECENT DEVELOPMENTS AND PRESENT TENDENCIES IN TECHNICAL EDUCATION.

BY DEAN FREDERICK E. TURNEAURE,

President of the Society.

The general trend of technical education in this country has been so well recorded from time to time in the papers which have been presented before this Society, that the speaker hesitates to discuss a subject which must involve, to a considerable extent, a further review of this development. It seems to him, however, that there are reasons why the present is in some ways a significant period in technical education, and that the development of the next decade will be along somewhat different lines from that of the one just past. There appear to be reasons why there will be a less strenuous growth in numbers and in material equipment; that, in some respects, the technical schools of the country have reached a condition of comparative stability, and during the next decade are likely to develop along other lines. Not without significance in this connection is the fact that in the industrial world the supply of young engineers has at last overtaken the demand. While this condition probably will not obtain for any great length of time, the present enormous producing capacity of the technical schools and the very large number of engineers in practice now as compared to a decade ago, creates a situation in which a sudden increase in demand can be met much more readily than in the past. In a word it would appear that, on the whole, there is likely to be much keener competition of merit in the lower ranks of the profession in the future than has existed for some years in the past.

Considering both the number of engineering schools which have developed into institutions of importance and the attendance upon engineering schools as a whole, it may be said that the great growth in technical education has occurred during

the past decade. Previous to this time the increase in attendance had been relatively slow and confined, mainly, to a few of the older institutions, but during the past ten years a very large number of schools which previously had had small attendance, small resources, and small faculties, have become largely attended, and have developed their facilities in every way. It is safe to say that at the present time there are as many as 30 institutions in this country which have an attendance of over 500 engineering students each, as compared to two or three such institutions a decade ago. In a large percentage of these the attendance ranges between 750 and 1,200, while in three or four it exceeds the latter number. The total number of engineering students in American schools has probably trebled during the past ten-year period. The growth in technical education in this country is also well shown by the increase in membership in this Society, which has grown from less than 200 in 1898 to 750 at the present time.

It is also significant that a similar growth in technical education has taken place in Europe and in particular in the German technical schools. The rapid development of these schools began somewhat earlier than in this country, dating from about 1893. It was very rapid up to about 1903, the attendance increasing from a total of about 7,600 in 1893 to 18,700 in 1903, in the ten schools of first rank in Germany and Switzerland. Since the latter date the increase has been less rapid, corresponding somewhat to what is likely to be true of institutions in this country for the next few years.

The general causes underlying this great development in technical education are well known and need not be enumerated. A great demand has existed for technically trained men. We have been busy meeting this demand as best we could and indeed, perhaps, have done our part towards encouraging and developing such demand. The value of school education to the technical man no longer needs to be supported by argument. However, as there has now come a slackening in this demand—the first in many years—and the supply bids fair to be temporarily in excess, it may be a

favorable time to take a survey of our work during this strenuous decade, and to note as we may some of the more important factors in this development and their bearing upon the tendencies of the future.

Perhaps the most significant and far reaching fact in this development is that of the growth in numbers itself. This enormous growth in the number of students studying engineering has attracted attention on the part of everyone interested in higher education. It has, in fact, had far-reaching effects, not only upon the industrial life of the country, but also upon other callings and professions. It has greatly affected the balance of educational development in many ways, and has had its influence even on the problems of co-education. It has doubtless caused some worry to university presidents and especially to those educators primarily interested in the older type of education. Taken with other professional and vocational courses of recent development there would seem to be little encouragement for the more liberal education. Is it true, as some fear, that higher education is coming to be hopelessly vocational in all directions? The speaker will not attempt to answer the question, but he will say that he is not alarmed for the future. Whatever may be the apparent effect in this respect, it is undoubtedly true that this great growth in numbers and in relative importance has had a very beneficial and far-reaching effect upon technical education itself. Such a development has placed the engineering departments of our universities, and engineering education as a whole, in quite a different relative position in the educational world from what they formerly occupied. Measured by numbers alone, the importance of the engineering school is very much greater than formerly and this condition demands and receives much more consideration for the problems of engineering education on the part of all concerned. These problems have thus forced themselves upon the attention of our oldest and most exclusively classical institutions. In some of these, courses of engineering have been added, and in others, inadequate courses have been developed. The engineer-

ing faculty and the engineering courses have come to be of much greater relative importance everywhere and the aims of engineering teachers and the educational value of the fundamental engineering subjects are better appreciated by our literary and scientific colleagues. Doubtless, also, there has been some improvement in the fundamental character of engineering education. Responsibility encourages efficiency, and it would be strange if the growing importance of the engineering departments had not reacted upon these departments themselves in a beneficial manner. However this may be, it is unquestionably true that the engineering department and the engineering faculty occupy a position in our large universities of much greater relative dignity and importance than a few years ago. It may be conservatively estimated that at least one half of the young men who are enrolled in the universities of the country, taken as a whole, in which engineering instruction is well developed, are registered in the engineering courses. In many large institutions the proportion is much larger than this.

The changes in the standard courses of instruction which have taken place in the past ten years are considerable, but not so great as might be supposed. The pages of the publications of this society describe many courses and modifications of courses, and experiments in matter and methods. However, in turning over the pages of school catalogues of ten years ago, it is apparent that the changes in the curriculum which have occurred in this period are not very great, and very much less than the changes which occurred during the previous decade. The cause of this apparent stability of the regular four-year courses is not far to seek. The principal reason is that the entrance requirements to these courses have remained substantially fixed during this period in most of the institutions which are now attended by large numbers of students. The significance of this fact is important, both with respect to recent growth and to the direction of future development. The essential fact is that a large majority of the larger universities and technical schools now require, and

have required for some years, substantially a full four-year high school course for entrance. While this requirement is more or less modified in some institutions, yet it may fairly be said that this statement correctly represents the requirements in institutions in which a very large majority of the engineering students are now registered.

The question of entrance requirements has received attention, and the general tendency has been to increase them where practicable. Schools having lower requirements than those above mentioned have rapidly come to this standard, and in a few cases the requirements in some studies have been raised somewhat beyond this point. It appears to the speaker, however, that for the great majority of schools, and especially the state universities, it will not be right, expedient, or possible, to require of the secondary school more than can fairly be covered in a four-year high school course. So long as students are admitted to the engineering course directly from the preparatory school the specific requirements for admission must be closely related to the general college requirements and to the requirements of a well-balanced high school course. It is possible for engineering departments and colleges to make their requirements considerably greater in mathematics than the requirements for admission into colleges of liberal arts, and still not to exceed what can be taught in a four-year high school course. Relatively high specific requirements are in force in a few institutions, but such differentiation cannot be carried far, and experience in some institutions leads to the conclusion that results thus obtained are not altogether satisfactory, even from the standpoint of the engineering school itself. From the standpoint of the public high school, high specific requirements for technical courses are of doubtful wisdom, and are likely to be especially difficult to enforce in state universities where the institution constitutes a part of the public school system. Preparation in mathematics is, to a large extent, the determining factor with respect to the engineering curriculum, and this is the subject which the technical school wishes to see carried as far as possible in the

preparatory course. Experience seems to indicate, however, that it is not easy to secure good high school instruction in advanced algebra and in some parts of trigonometry. It is a question whether, even for the engineering student, it is not better that he shall emphasize language and literature in his high school course rather than extend his mathematics beyond a certain reasonable minimum.

Considering all these factors, it appears that there exists a very good reason why entrance requirements have not materially advanced in the past few years and why they are not likely to advance in the future, so far as admitting students directly from the high school is concerned. Some improvement will doubtless be made in the character of the high school instruction, but the four-year public high school course is bound to control for many years to come the entrance into our colleges and into some departments at least of the universities.

Where entrance requirements have remained nearly stationary, no great or fundamental change could be expected in the engineering curriculum. Educational experiments have been tried in many ways. Notable among these have been the tendency toward a greater or a lesser degree of specialization, to the teaching of practice to a greater or to a less extent, to the introduction or exclusion of certain general studies such as language, economics, history, etc. In some schools general courses have finally been divided into two or more engineering courses, and in other schools highly differentiated courses have been brought closer together. On the whole, it is probably true that there is less difference among the several courses than was the case a few years ago. More thermodynamics and electricity are being taught to civil engineers, and the electrical and mechanical engineers are receiving more instruction in materials, hydraulics and structures. Recently an attempt has been made in a university to arrange a single course which would provide for civil, mechanical and electrical engineers together, but two courses were finally found necessary. There seems to be a logical and fairly well

defined line between the group of studies best suited for the civil engineer, the one who deals mainly with static structures, and the group of studies best suited for the mechanical and electrical engineer, who deals more particularly with machinery and the transmission of power. The differentiation between the mechanical and electrical engineer is less important, and there appears to be at the present time a tendency towards a closer agreement between these two courses. Outside of these courses, the course in mining holds its old status, but in applied chemistry there has been a considerable development in the form of courses in chemical engineering, electro-chemistry and ceramics. There appears to be real and permanent demand for this new differentiation.

The subject of academic degrees has received its due share of attention, but seems to be in as uncertain status as ever. It is hoped that the recently appointed committee of this Society may be able to recommend something which will assist in clarifying the situation.

In equipment a very great advance has been made in the past ten years, especially in institutions that have had a large growth during that period. This improvement has been so satisfactory and noteworthy that, for instructional purposes, it may be said that the equipment in most of the large institutions, and in many of the smaller ones, leaves little to be desired. Ten years ago very few institutions were supplied with suitable quarters in any respect. Now nearly all possess fine buildings for recitation rooms, offices and drafting-rooms, and are provided with well equipped laboratories. Funds for these purposes have been generously supplied. The engineering building, or group, and the engineering college, or department, have come to be a large unit in university life.

When we come to the faculties it is doubtful if as favorable statement can be made as with respect to equipment. The tendency to wholesale methods of administration, where large numbers of students are concerned, is hard to resist, especially when money is scarce, and the maintenance of a proper relation between the number of professors and the

number of instructors is difficult. It has been easier to get money for buildings and apparatus than for men. This condition is influenced, not only by financial considerations but by considerations of organization, and it has often happened that an organization suited to one or two hundred students has hampered the proper growth of a faculty to handle five times that number. There is a noteworthy tendency towards improvement in these respects, both by securing more adequate funds and by better adaptation of organization. The fact that men are of greater importance than equipment has been well appreciated by educators all along, but now that laboratory equipments are more satisfactory, perhaps the evidence of this belief is becoming more prominent. The necessity for good men and the difficulties of securing them are being felt to an increasing degree.

Summarizing briefly, the past decade has been characterized chiefly by a great growth in numbers of students, with many far-reaching effects resulting therefrom. Entrance requirements have been modified to a small extent, and the curriculum has been improved and brought to a sounder basis; laboratory equipments have been greatly enlarged and faculties increased in numbers, so that on the whole the work of the schools has fairly met the requirements of the country.

In what has been said we have referred principally to the regular four-year course as it has become generally developed in this country. If entrance requirements are not likely to change greatly in the future, so far as they are based on the public high school and the usual preparatory school, the four-year engineering course, following upon this preparation, cannot, in its nature, be greatly modified. There have been, however, very recent developments in other directions which are indicative of important changes in the future. These are, first, the establishment of longer or more advanced courses of study, secondly, the growth of research in the engineering school, and thirdly, the development of technical instruction of a secondary grade. Before examining these features in detail, let us consider for a moment the educational

requirements of the present time along technical lines and what they are likely to be in the near future.

For the past year or more the supply of technically trained men has been more than ample for the demand. We are passing through a phase of reduced activity in industrial life and in the development of the country, accompanied by a lessened employment for engineers. That this condition is to obtain for any length of time probably none of us believe to be true, and the number of men needed in practical life who have received a greater or less amount of technical instruction will, on the whole, continue to increase indefinitely in the future. There is a fundamental reason why this should be true, and why it has been true ever since the invention of the steam engine, leading to the manufacture of power and the multiplication of man's productive capacity. This same cause will continue to exist until modified by the exhaustion of the world's resources. So long as division of labor continues to develop, thus separating more and more the producer from the consumer, the engineer will be called upon in ever-increasing numbers to develop and transmit the power, to manufacture and operate the machinery and to provide the transportation facilities on a larger and larger scale. Through the development of agricultural machinery, a smaller and smaller percentage of the world's population will be required to procure the raw material for food and clothing, and a constantly increasing percentage will be employed in meeting our wants and necessities in the form of manufactured articles and in transporting them from producer to consumer. A larger and larger proportion will of necessity dwell in large groups involving a complex life, and even the life of the agriculturalist will be increasingly complex. All these conditions tend to increase the demand for men trained in the knowledge of materials and the laws of physics and chemistry. In the transportation of persons and materials, in the production and transmission of power, in the supply of water, gas, electricity, heat and refrigeration, in the disposal of waste material, in the manufacture and operation of machinery, in the develop-

ment of the resources of the mine and forest, and even in the conduct of modern agricultural operations the engineer is needed, and will be needed in the future in greater and greater numbers and in increasing proportion to the total population served. In this respect the engineering profession is on a different basis from the older professions. In law, medicine and theology, and even in pedagogy, there seems to be little reason why the demand should increase more rapidly than the population and, on some accounts, it is likely to be less rapid. With the engineer exactly the reverse is true. In some of the newer professions or vocations it is also doubtless true. The expert agriculturalist and the professional economist are probably examples somewhat parallel to the engineer. The steady and continued growth in the attendance of engineering schools in Germany, a country in some respects very fully developed, is an illustration of the truth of the foregoing statements.

I believe it may therefore be taken for granted that so far as numbers alone is concerned, the demand for men having a greater or less amount of technical training will continue to grow for an indefinite length of time. The question which continually confronts us is: What shall the engineering school do to meet this demand in the best way? It would appear that during the past decade the schools have had all they could do in supplying the men needed, without departing from the course which they have pursued for many years, and the demand has probably been as well met as it could easily have been. With the present slackening in this demand and the probability that future requirements will not increase in quite so rapid proportion as has been the case for many years, it would seem that there is likely to be in the future more competition of merit among the younger generation of engineers, and that there will be better opportunity for schools to differentiate somewhat in their plans and purposes, if such differentiation will meet the variety of needs better than the present system.

Engineering is commonly and with truth called a "profes-

sion." For many technical men it is a profession, but for others and larger numbers, it can scarcely be said to be such. The technical requirements requisite for the performance of various duties vary between wide limits. They range all the way from those of a draftsman who needs to know something about structural details, and those of the county surveyor whose mathematical knowledge does not extend beyond the elements of trigonometry, to those of the most expert consulting engineer of broad learning and high technical attainments. A shorter or longer period of study in a technical school of some grade is a very desirable preparation for the draftsman, the surveyor, and the professional engineer. Technical education, as well as technical employment, may thus cover a very wide range. The word "engineer" would scarcely be used to designate the man in the lower grades of work, but the education of both classes of men is more or less technical. Innumerable callings require a greater or less amount of technical training, some of which might fall within the class generally considered as engineering, while others would not. The profession of the engineer is, for these reasons, somewhat indefinite, and probably will always remain so, unless some formal method be adopted by the state to differentiate by examination, or to recognize examinations conducted by educational institutions. It does not seem important, from the standpoint of the engineering educator, that such differentiation be emphasized; but it is important that the requirements of society in the field of technical education be understood and provided for.

This country is new and conditions of employment are exceedingly favorable for promotion from rank to rank and from position to position on the basis of individual ability. Class education is not much more favorably considered by the public than class legislation; and yet some distinction has been made and greater distinction will undoubtedly be made in the near future in providing the necessary education as a preparation for work in the various lines of activity in which some or much technical education is required. On the one

hand, no training can be too thorough, no culture too broad for the real professional engineer. His position demands the greatest breadth of view, the wisest judgment of men and the most thorough knowledge of engineering principles. He must be an educated man in the best sense of the word; his preparation must be as thorough as that required in any of the learned professions. It may and will often be profitable for him to spend five or six years in studies subsequent to his high school course. On the other hand, it is unquestionably true that large numbers of young men who could not possibly afford such a long course, can be greatly helped by technical instruction extending over a period of two or three years. The organization of courses, the fixing of entrance requirements and the granting of degrees, exert a great influence upon the kind and duration of the course of study which the student will pursue. Up to the present time engineering instruction in this country has been confined almost entirely to the standard four-year course, and the curriculum has been arranged primarily with a view to giving the best possible instruction to students who expect to remain four years and no longer. The student who wishes to get some technical training to assist him in his chosen vocation, but who cannot stay four years, is not well provided for; the needs of such students have been recognized in but few places. I believe it may be said also, with truth, that the present courses are also not well adjusted for those who wish to secure a more thorough preparation for the profession. Post-graduate work in engineering can hardly be said to be a success. After completing a four-year engineering course few students find much profit in continuing longer at the school.

More specific provision for both these classes seems likely to receive consideration in the near future. Within the last two years much has been done towards the encouragement of longer study by a better development of the five and six-year courses. For several years it has been possible in many institutions to complete a general college course and an engineering course in six years; but until very recently this arrange-

ment has been little used, as the six-year course is so much longer than the four-year course that it seems quite beyond the reach of most students. The five-year course seems likely to meet the situation better at the present time, and the recent movement toward the establishment of such courses is very noteworthy. This has taken the direction in several places of a fully scheduled five-year course which includes but little more of engineering instruction than the four-year course, but more general studies, such as are given to a very small extent in the four-year course. This five-year course may or may not lead to a different degree from the four-year course. Very generally the bachelor's degree is granted at the end of the fourth year and a master's degree or an engineering degree at the end of the fifth year. Various arrangements are in operation, depending upon local conditions. In one institution the five-year course has been arranged as a four-year advanced engineering course, requiring one year of college work for admission, thus tending towards a status similar to the professional law and medical schools with advanced entrance requirements. In the discussion relative to these arrangements the central thought seems to be that the additional time should be given mainly to general or scientific studies rather than to additional technical work. There is little tendency towards crowding in new engineering subjects of an advanced character. Economics is given much attention as a subject of direct practical value to the modern engineer. Additional mathematics, sometimes advanced courses in English, and longer courses in the collateral engineering subjects of fundamental importance, are the studies which generally take up the additional time. Some new courses significant of the trend of the times are now to be found in the catalogues, such, for example, as courses in public service corporation management, and engineering finance. Very many institutions are thus encouraging their students, in some form or other, to pursue a longer course than four years, subsequent to high school graduation. From what has already been said relative to entrance requirements, it seems obvious that if the engineering student

is to secure a broader preparation in school, it will have to be done by preliminary or simultaneous college work rather than by means of higher requirements placed upon the secondary school. This brings us inevitably to the five or six-year course, or to the shorter professional course with entrance requirements involving one or more years of college work.

It is believed by many that four years is long enough for a young man to spend in college, and that he can then profit more by getting into practical work than by remaining longer in school. This is doubtless true for a large proportion of students, especially after they have completed a four-year engineering course. But there still remains the fact that breadth of view and thoroughness of training must ultimately be secured by the successful professional man. To what extent this will be secured in school and to what extent in practical life is very largely a matter of personal equation and circumstances, but in any case it is a necessary qualification of the successful man.

The real question that interests us is, what can be economically taught in a school, considering broadly the greatest usefulness and highest success of the student? Experience has shown that it is worth while for the lawyer and the physician to devote a very considerable time in school to liberal studies as well as to his professional course. The engineer is in no less need of such training: indeed his relatively isolated position during the early years of his professional life would appear to indicate that his need is even greater than that of the lawyer. If this is true, should not the schools encourage such education by a convenient arrangement of courses, the granting of suitable degrees and, on the part of some schools favorably conditioned, by giving exclusive attention to courses of this character?

These advanced courses, as compared to the present four-year course, will be enlarged in three directions; in studies belonging to the humanities, in mathematics and science and, to a certain extent, in additional engineering studies. In the humanities the field is broad and the time only too short.

Literature, history and economics seem likely to be the most profitable studies. In mathematics it is a question if somewhat more time should not be given to the higher subjects, and in physics and chemistry, certainly some of the engineering courses would be improved by further study of these subjects.

It is often said and frequently reiterated that we should teach only fundamentals. We probably all agree to that statement, but might not agree on what are fundamentals. It might fairly be claimed that the fundamentals of engineering are covered by the pure sciences, mathematics, theoretical mechanics, and materials of construction. But we all go much beyond these studies in our courses and undoubtedly with profit to the student. The fundamentals of geometry may be considered as the axioms. Given the axioms, a well-trained man can (with difficulty) construct his own geometry. Bridge stresses is simply advanced statics, but this subject is taught in all civil engineering courses. The fact that such a subject can be more readily and effectively learned in school to a certain point, than in practice, and the further fact that a considerable group of students is quite likely to have early use for it in practice makes it a fair proposition to teach it in school. The general training which such a subject gives in the application of mechanics to any problem is of course not to be overlooked, but if bridge stresses could be learned outside better than in school, it should be dropped from the curriculum. The same is true with many other studies. Reinforced concrete is also merely applied mechanics, but it involves the application of mechanics in a somewhat special manner, so that it is likely to be a subject that will prove to be economically taught in school. We must, of course, confine ourselves to the fundamentals of any subject, which simply means, I take it, that we should not take the time of a student in teaching details of practice which he can better learn outside.

In technical lines, probably the direction in which advanced work can most profitably be extended is in those studies

closely related to laboratory investigations, to theoretical analysis and to the study of properties of materials. In the last named subject, especially, there is a great need of better knowledge. Wood, steel, copper, lead and zinc can no longer be given exclusively as the chief engineering materials. The use of nickel steel, manganese steel and aluminum on a large scale in engineering construction is already current practice. The electric furnace has in recent years given us metallic products at a cost almost infinitesimal as compared to that of a few years ago. Uses are yet to be discovered for some of these cheaply produced and comparatively new products. Efficiency of electric illumination depends largely upon the discovery and utilization of the so-called rare materials. A new epoch in the study and utilization of materials seems to be upon us, and one of the most promising fields of development in applied science is along these lines. This will carry with it increased laboratory study in chemistry, electricity and metallurgy.

Closely related to the development of longer courses of study is the recent growth of research in applied science as related to engineering. Following somewhat the growth of the agricultural experiment station, research in the engineering sciences has been very greatly developed during the past four or five years. In at least two institutions a special organization, called an "engineering experiment station" has been established, whose function it is to carry on research in the engineering sciences, particularly in those directions which most concern the interests of the state in question. Such research has also been greatly promoted and developed in institutions having no special organization for that purpose, the work being carried on as a part of the regular duties of the several departments. Federal aid for such work has received much consideration in two or three sessions of Congress and it is likely that it may be granted in the near future. Expenditure of public funds for such purposes is thus looked upon as legitimate and profitable, and the development of this feature at engineering schools is likely to be continuous and to reach important proportions.

This work of research is not only of great direct value by reason of the results obtained, but is of great service in connection with advanced instruction. It furnishes a much more profitable field for the graduate student than courses in advanced design, on which he was wont to spend his time a few years ago. Fruitful research is also of much value in cultivating helpful relations between the teacher and the practical engineer. The latter is coming more and more to utilize the very latest results of experiments in his line, and to look more and more to the engineering investigator for practical assistance in this way. No more satisfactory way of maintaining contact between teacher and practitioner can be found than through the medium of scientific investigation of practical value to the engineer. The utilization of such results by the engineer, in the securing of which the student has had a part, is certain to impress upon the student more forcibly than anything else can the value of such data, the means of securing it, and its proper use in practical problems. Research in laboratories connected with agriculture and engineering schools must be relied upon to a very considerable extent to bring the results of studies in pure science to a practical and economical basis. Such studies will play an extremely important part in the future in the proper utilization and the conservation of the country's resources.

The third phase of educational development has to do with courses and methods of instruction adapted to those who can complete only a relatively short curriculum. The four-year course does not adequately meet the great variety of needs of this class of students. It may perhaps be considered as a maximum course, but better opportunity should be offered for securing technical instruction of still briefer period. The shorter courses of instruction have been given some attention by a few institutions, perhaps most successfully by one of the institutions of which the Society is a guest. Its work might be taken as a model for others. The trade school, as such, is not a school to which the American public seems to take kindly and its development has been very meager in the past.

There are signs, however, that the regular trade school, as well as the secondary technical school, is likely to be given much more attention in the future.

Schools of a secondary grade are needed in every large manufacturing center. To a considerable extent they should be local in character and should provide instruction in ways that will benefit the greatest number of students. Night school work is an important function of such institutions. At the present time there are few opportunities for young men to secure any technical education whatever, except by completing a four-year high school course, and then by pursuing a regular four-year engineering course in an engineering school. There is no reason why a large and profitable amount of technical instruction cannot be given without so long a preparation. A thoroughly sound and practical course in mechanics can be taught without calculus, and two years instruction of the right kind will be of great assistance to many workers in industrial life. Such opportunities should and will be offered more adequately than is the case at the present time. The great patronage of the correspondence schools is an indication of the demand which exists in this direction.

The very successful coöperative work inaugurated at Cincinnati, and already adopted in some other institutions, is an important movement of much significance, especially for institutions located in large industrial centers. Although inaugurated in connection with a school of engineering it would seem to have especially great possibilities for schools of secondary grade located in large cities.

Up to the present time the state has not, in general, extended its support to trade and secondary schools. There is no fundamental reason, however, why this should not be done. Already, in at least three states, legislation has been enacted leading in this direction, and trade schools and secondary schools are now being supported by taxation. The establishment of the county agricultural schools is a movement in this same direction.

The relation of the state university or the state college to

such secondary schools is of much importance. Where suitably located, the higher institution may well include in its work the technical instruction of secondary character in much the same way as many now include short courses in agriculture. Such courses have been, and will be very profitable, and will in no way affect the educational standard of the higher work. Where the higher state schools are not suitably located, some supervisory control by a central body is necessary in order to avoid expensive and unwise duplication. Unified control of all higher educational institutions supported by the state at large will in the future be more necessary than in the past, and action of legislatures during the past winter indicates that such control is rapidly taking form.

Correspondence instruction by the state has been established in at least one state and has there been placed upon a sound financial basis. The demand for such instruction has come about largely through the lack of secondary schools in the large industrial centers, although such correspondence instruction meets other demands as well. It is a notable development which meets a real demand, and which is certain to be further extended.

It thus seems likely that there will develop many more schools in our industrial centers of somewhat lower requirements than the present standard engineering schools. To abolish the four-year course, and require all students to pursue a five or six-year course, would be unfair to a large number of students who cannot afford the long course. Such action might well be justified on the part of privately endowed institutions, but on the part of state institutions the less well prepared student should not be barred from profiting by technical education. A two-year or three-year course offered side by side with the five or six-year course, would very likely meet his needs better than a four-year course; but until adequate provision is made for the shorter course by some other institutions, the state supported technical school should, I believe, meet the situation.

Such, in brief, are some of the principal tendencies at the

present time as they appear to the speaker. Certain it is that the demand for higher technical knowledge and general efficiency, as well as the demand for larger numbers of men trained to different degrees along technical lines will be studied and met by our educational institutions. The work is worthy of the best thoughts of the best men and to be engaged in this great work and to be an active member of this great body of educators, is a privilege and a responsibility which cannot be too highly appreciated.

THE TEACHING OF MATHEMATICS TO ENGINEERING STUDENTS.

THE CHICAGO SYMPOSIUM.

EDITOR'S NOTE: A symposium on mathematics for engineering students was held in Chicago, December 30, 1907, under the joint auspices of the American Mathematical Society and the American Association for the Advancement of Science. A number of brief papers were presented giving views of the subject from three standpoints: (a) That of the teacher of mathematics, (b) that of the teacher of engineering subjects; and (c) that of the practicing engineer. The papers and discussion were printed in *Science*, Vol. XXVIII, and also in pamphlet form. Professor Wm. T. Magruder was secretary of the meeting. An outcome of the meeting was the appointment of a committee of twenty to consider the whole subject and report to the Society for the Promotion of Engineering Education. A few extracts from the symposium are given here as an introduction to the preliminary report of the committee* of which Professor Huntington is chairman.

* The name of this committee is "Committee on the Teaching of Mathematics to Students of Engineering." It was appointed at a joint meeting of the Chicago Section of the American Mathematical Society, and Sections A and D of the American Association for the Advancement of Science, Chicago, December 30-31, 1907. (See *Science* for July 17, 24 and 31; August 7 and 28 and September 4, 1908.) The membership is as follows: Philip R. Alger, professor of mathematics, U. S. Navy, Annapolis, Md.; Donald F. Campbell, professor of mathematics, Armour Institute of Technology, Chicago, Ill.; Edmund A. Engler, president of the Worcester Polytechnic Institute, Worcester, Mass.; Charles N. Haskins, assistant professor of mathematics, Dartmouth College, Hanover, N. H.; Charles S. Howe, president, Case School of Applied Science, Cleveland, Ohio; Emil Kuichling, consulting civil engineer, New York City; William T. Magruder, professor of mechanical engineering, Ohio State University, Columbus, Ohio; Ralph Modjeski, civil engineer, Chicago, Ill.; William F. Osgood, professor of mathematics, Harvard University, Cambridge, Mass.; Charles S. Slichter, consulting engineer of the U. S.

Reasons for the Use of the Term, Engineering Mathematics:

Professor A. E. Haynes.

(a) Because of the main object of the study of mathematics in engineering courses, viz., its use as a tool.

(b) Because of the proper method of teaching the mathematics of such courses.

(c) Because of the content of the mathematics of such courses.

It is not a degradation of mathematics to make it practical. The teaching of mathematics (1) should be of such a character as to produce an enduring stimulating effect upon the mind of the student, (2) should give the student the power to interpret properly mathematical language, and to use it accurately and skillfully. To secure these results, the teaching must be based upon a proper order of studies and carried forward in a rational, intelligent manner.

The Nature of a Mathematical Problem: Professor J. B. Webb.

Every practical problem requiring mathematics for its solution consists of three parts:

(a) An analysis, which resolves the problem into its elements, examines these in the light of natural laws, rejects unimportant ones and defines the relations existing between

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those upon which the solution depends. This involves the adoption or discovery of methods of measuring the elements, so that they may be expressed quantitatively by symbols, and of the reduction of the relations between to the standard mathematical forms of expression. The result is a mathematical statement of the problem by one or more equations.

(b) A solution of the equations by which the relations sought for between the quantities are clearly expressed or the quantities put in proper form to have their values calculated.

(c) The interpretation of the result, which involves a translation of the same from the mathematical language in which it has been obtained into the original language of the problem and a discussion of the practical bearing of the same.

The Three Phases of Mathematical Study: (1) Theory, (2) Practice, and (3) Philosophy: Professor A. N. Talbot.

1. *Theory*.—Analysis, demonstration and the general derivation and presentation of mathematical principles. The derivation and exposition of mathematical principles and operations and the appreciation of mathematical concepts are universally accepted as important elements in the education of an engineer. The use of mathematical forms of attack, the training in processes of reasoning, the formation of logical habits of thought, are hardly secondary in importance. And yet much less emphasis is placed on formal demonstration and reasoning than formerly—frequently this element is overlooked or treated in a slipshod way. The student comes to feel that he is after facts and that the derivation and proof of principles involves useless effort—he is willing to accept their authenticity. It may be that years ago our instructional methods carried formal processes to an extreme and that as a result mathematical work became meaningless lingo or memorized facts to many students. This does not furnish argument for the abandonment of training in formal reasoning. For the young mind, practice in analysis, in formal demonstration, is illuminating and developing. Even the repetitive forms of analysis in the old-time mental arith-

metic had great mathematical educational value. The speaker feels that in the effort to avoid barren formalism the pendulum has swung too far the other way, and that both in high school and in technical school, and in the applied engineering subjects as well, the training in analytical methods and formal processes is weak. He believes that good results would follow the putting of greater emphasis on this phase of instruction than now seems to be the trend.

2. *Practice.*—The use and applicability of mathematical principles and processes in the solution of problems, drill on these principles, and the acquisition of facility in their use. To the average student the working of examples is illuminating. Without it the concept is but vaguely comprehended, the derivation only faintly understood, the process may seem merely verbal legerdemain. Properly used, this phase of mathematical instruction is of great advantage to the student of average mathematical ability. It opens up the view; it clears away uncertainties; it fixes principles and concepts; it gives life to the subject. The problems used should be within the field of the student's experience and comprehension and may well bear some relation to his future work, both in the engineering class room and beyond. And the second part of this heading is not less important. Mathematics is a tool for the engineering student, and he must acquire facility in its use. This does not mean that the instructor should attempt to make him a finished calculator or an expert workman—time is too short—but mathematical principles and processes must be more to the student than a vague something which he recognizes when his attention is directed thereto. Instead, he must have a mastery of at least the fundamentals and he must be able to use such principles and processes in his later studies without having to divert his attention and energy too much from the engineering features involved. To acquire this facility requires drill and repetition, and this drill must constitute a part of the mathematical training of the engineering student. The multiplication table had to be learned, and many other important things have to be acquired in the same way.

But it seems that this important side of instruction may be abused. The student who thinks that to accept facts and work problems is sufficient, and the instructor who thinks that illustrations and practice work alone constitute mathematical training or that mere laboratory methods suffice, are greatly mistaken. The mere substitution in formulas is only rule-of-thumb work, so much decried in engineering; and the mechanic who knows how to use tools, and no more, is not an engineer. There must be a direct connection with the theory and the philosophy of the subject to make the practice side serve its proper purpose. In teaching mathematics years ago, expressions of approval came to me because I was so "practical," but the underlying purpose of the practical part was not always understood, though this lack of understanding did not affect the results of the method. Inside the "sugar coating" there should always be a principle to fix, a concept to illumine, a process to exemplify, a derivation to expound. There seems to be a tendency among some to overdo this side of the work to the detriment of the first side. While the practice feature is a valuable auxiliary in mathematical instruction, it should never be the leading motive. Student and instructor alike should recognize this.

3. *Philosophy of the Subject.*—The basis on which the science rests, the underlying meaning of the mathematical processes used, a philosophical study of the method of treatment and of the concepts used, their connection with related things. This is difficult to discuss in a general way, and of course this phase is intimately connected with the first and second. To my mind this phase should not be neglected. It must be apportioned according to the ability of the student. An understanding of the philosophy of the subject will widen his field of view and lessen the chances of error. The better grasp of the meaning will be advantageous. Its presentation involves difficulties, and text-books generally disregard it. It must not be over-emphasized, as is illustrated by the treatment in a recent text-book in applied mathematics, where it is used largely to the exclusion of analysis and demonstration.

Effective methods in mathematical subjects involve, then, the skillful selection in proper proportion from these three phases, and the best teacher will make for himself the best selection. The derivation and elucidation of mathematical principles, facility in their use and application, and an understanding of the basis on which principles and methods rest are all essential. A good text-book—one properly proportioned—aids greatly in the work of instruction. However, it is the teacher on whom reliance is placed in the end, and for the student of average mathematical ability the teacher's influence constitutes a large element. It is highly advantageous for the teacher to have a fair knowledge of the applications of mathematics which the student will make in later work and to have sympathy and interest in such work. Let us also emphasize the importance of having the best teachers for mathematical instruction.

Let me add to this that it is my belief, growing stronger after many years of observation, that the average engineering student gets relatively little from lectures on mathematical subjects; that many instructors talk too much themselves; that the student must have the opportunity to express himself and must be required to use the mathematical language and to try his own skill, and this in other than formal quizzes; and that recitation and drill work are essential factors in giving training to this average student.

PRELIMINARY REPORT OF THE COMMITTEE ON THE TEACHING OF MATHEMATICS TO STUDENTS OF ENGINEERING.

BY EDWARD V. HUNTINGTON,

Professor of Mathematics, Harvard University.

The joint meeting of engineers and mathematicians at which this committee was appointed was a remarkable instance of the value of such joint meetings to both parties. (See abstracts of discussion, above.)

Most of the speakers evidently came to the meeting expecting a warm discussion. The mathematicians expected that the engineers would tell them that what they wanted is practical arithmetic, while the engineers fully expected that the mathematicians would tell them that what they wanted is "pure mathematics" "the queen of the sciences." But as the session progressed everyone was astonished to find that no conflict was precipitated. By the end of the meeting the conference had become a genuine "love-feast" between the engineers and the mathematicians.

The gist of the discussion was this: For the purposes of the engineer, mathematics is a tool which is to be used, but which must be thoroughly understood to be used intelligently. The mathematicians agreed that the principles rather than the details of manipulation and formulation were necessary for the engineers. The general impression was that mathematics beyond the calculus is not much used or needed by the ordinary engineer, but that the engineering student should thoroughly understand all the principles involved in mathematical work through the calculus and mechanics.

The outcome of that meeting was the formation of this committee on the teaching of mathematics to students of engineering. Three persons present were asked to form this committee. A committee of twenty members was chosen, rather widely distributed geographically, but not intended to be exhaustive in the number of institutions represented. It included only those known to be vitally interested in the subject and sympathetic with the spirit of the meeting. The committee was left largely upon its own responsibility as to its work. The instructions were to embody in some permanent form the enthusiasm of the meeting.

The first undertaking of the committee was to collect information as to the present methods and scope of mathematical instruction in engineering schools. A large amount of information was collected through the coöperation of nearly forty of the leading schools, and it was expected that a report based upon these statistics would be given at this time.

In the meanwhile, however, a much larger body has been formed, The International Commission on the Teaching of Mathematics, which had its inception at the International Congress of Mathematicians held in Rome in 1908. This commission consists of committees of three each from all of those countries in which mathematics is seriously taught. The American commissioners are Professor D. E. Smith, Professor W. F. Osgood and Professor J. W. A. Young.

In order to avoid duplication and trouble to the institutions from whom information is being obtained, the committee has arranged to transfer to the American commissioners all of the statistical data now in its possession. These will be worked up into the complete body of information which will result from the larger scope of their own inquiry. The present committee has therefore nothing to report on this head.

In addition to the collection of statistics, our committee, in December, 1908, voted to compile a synopsis of the mathematical work which is regarded as a minimum desirable equipment for students of engineering. The chairman and secretary were requested to obtain opinions on the subject from as many different sources as possible. This work is now in progress and the committee respectfully requests an extension of time for another year, in which to complete its report. We desire the coöperation of the members of the Society present, in helping us with suggestions as to the scope and purpose of such a synopsis. The intention is to get together a list of the essentials of mathematics for an engineering student; not an exhaustive list but one containing those subjects which professors of technical engineering branches have found useful to students of engineering. I should like to suggest a short list of these topics, by way of opening the discussion.

Topic 1.—Differential Calculus; meaning and use of the derivative as the limit of the ratio of differences.

Topic 2.—Meaning and application of the definite integral, as the limit of a sum.

Topic 3.—Meaning and use of the indefinite integral, the inverse of differentiation, with the solution of simple differential equations.

Topic 4.—The fundamental theorem in the integral calculus which connects the indefinite integral, the inverse of differentiation, with the definite integral, the limit of a series.

If the student knows these things about the calculus, he ought to be able to understand the application of the calculus to all engineering work. We expect to give a much more detailed list of the essentials of the calculus, but it seems to us that all the student really needs is enough of the calculus to enable him to do his work properly, and to apply the calculus to engineering work. He thus does not feel burdened with a mass of details, but rather that he is in possession of a great instrument of investigation. He has some consciousness of the scope and the purpose of that instrument which, as we all know after years of practice, consists of a very small number of fundamental principles.

In mechanics, the fundamental principle is that the force acting on a particle is to the weight of that particle, as the acceleration which it would produce if the particle were free to move is to the acceleration of gravity. In that form, the equation needs no special convention in regard to the choice of the units of force. The accelerations must be measured in the same unit of acceleration, and the force in the same unit of force. The components of acceleration along the x and y axes and also along the tangent and normal, must be understood. The relation between circular and linear motion must be thoroughly mastered.

Along with the principle of force and acceleration applied to the particle, there are the principles of center of mass, commonly called center of gravity, the principle of rotation and the principle of work and energy. The principle of rotation is this: when a body is free to move about a fixed axis, under the action of any forces, the angular acceleration of the body is equal to the sum of the moments of the forces

about the given axis, divided by the moment of inertia of the body about that axis. Here moment of inertia means simply $(w/g)k^2$, where k is the radius of gyration of the body about the given axis; the concept of radius of gyration, and the units in which it is measured, are more easily grasped by the student than the concept of moment of inertia. The principle of work and energy is, that the work done on a body during an interval of time is equal to the change of kinetic energy during that interval. The only other essential definitions are impulse, momentum and horse-power.

In such a list as this especially one should notice the number of things that have been left out. The poundal and the absolute units of force and mass are not mentioned. Personally I am opposed to the unit poundal. The formulæ concerning impulsive forces are not mentioned. Impulsive forces are to be treated exactly like any other forces.

My purpose at this time is simply to open the discussion, as the Secretary of the Society has requested me to do, for the purpose of enabling those members of the Society who may have a desire to criticise our work, to do so after the opening of the regular discussion. We shall be pleased to receive suggestions regarding topics in calculus and mechanics which we ought not to have omitted.

This tentative list has been made by the Secretary and the chairman and has not been submitted to the committee. The committee is in no way responsible for it and will doubtless have many criticisms to make before the report is made in final form.

DISCUSSION.

THE PRESIDENT: I should like to hear from Mr. Haskins, who is a member of this committee.

PROFESSOR HASKINS: I think there is but little for me to add to the general statement of the chairman concerning the work of the committee and the Chicago discussion. One point brought out by one of the speakers of that meeting, a practical engineer occupying a post of great responsibility, was this:

The average engineer does not find use for a large amount of the mathematics that he learns in the technical school, but the engineer whose work leads him to deal with problems which involve the frequent use of this science, finds his success as an engineer limited largely by disability as a mathematician.

With respect to the synopsis of matters in the calculus which was presented, it is evident that that synopsis is not intended as an exhaustive program for a course in calculus in any technical school. It is, however, in my opinion, the ground work upon which all successful work in calculus must be built. A large portion of the work which the instructors in mathematics in technical schools are giving, is of the nature of a superstructure. It is an important and valuable superstructure, but it is nevertheless a superstructure, and can be built up afterwards if necessary. The subjects in the synopsis however, are the ones which must underlie *any* form of superstructure which one may choose to raise thereupon.

THE PRESIDENT: I see several of the members of the committee present, also some of the speakers who represented this Society at Chicago a year and a half ago. I wonder if any of them have changed their minds as to what engineers ought to be taught in mathematics? This is a subject in which we are all interested, as mathematics is the backbone of the engineering course.

PROFESSOR EDDY: Among the subjects which rightly have been proposed to us as fundamental is this one of the definite integral as the sum of an infinite number of infinitesimal elements of varying size, which are nevertheless all comparable to each other. Furthermore, it appears to me that since the mathematics of today bases itself upon series, one of the most fundamental of which is embodied in Maclaurin's theorem, it is not possible to omit that subject from among the fundamental ideas which must be conveyed to the student if he is to have a comprehension of the scope and underlying ideas of the calculus. You may perhaps call this a part of the superstructure, but it is a part of the superstructure that should be considered fundamental.

DEAN RAYMOND: Mr. President, I wish to inquire as to the number of schools in which mechanics is considered a part of mathematics? That is to say, in how many schools is it taught in the department of mathematics, as a part of the mathematics? It has so happened in the schools that I have been familiar with that mechanics has not been taught in that department. I had supposed that in an engineering school the department of mathematics should concern itself with actual or pure mathematics, and not with what might be properly called applied mathematics, as mechanics.

PROFESSOR EDDY: If the committee would propose a plan whereby all the professors of mathematics would teach their mathematics with mechanics always in view; and whereby the professors of mechanics would teach their courses in mechanics in the clear light of mathematics and with that sense of reality which comes from dealing with mechanics as a physical affair, as mechanics ought to be dealt with, and with applied mechanics continually in view, we should then be able to attain the objects which we desire. Without this mutual adaptation, the instruction in these two subjects will in my estimation be poorly adapted to the needs of engineering schools.

THE PRESIDENT: I am very much interested in this part of the question. I suppose it is not so much a matter of organization as it is the point of view of the man who gives the instruction; whether or not he has a clear understanding of engineering mechanics and appreciates the nature of the problems with which the engineer must deal. The cutting off of mathematics in the catalogues in one place, and calling the next subject mechanics is not the important thing.

PRESIDENT HOWE: I am a member of the committee of which Professor Huntington is chairman, and he has told the Society what has been done from the date of the appointment of the committee to the present time. We are still gathering information, and we still desire to get all the information possible from the members of this Society who are actually doing the work of teaching mathematics and mechanics. It seems to me

that mathematics is not only the tool which is to be used by the engineer, and which the teacher of mechanics must expect his students to have some knowledge of when they come to him, but it is also valuable as part of the training in the engineering school. The professor of mathematics ought to secure all the information which Professor Huntington has spoken of, and other information which his students will need later, so as to know the specific subjects which he should teach them in order to prepare them for engineering work. This is true because the pure mathematics comes in the engineering school before most of the applications to engineering work. The professor of engineering should tell the professor of mathematics what he wants his students to know, but the professor of mathematics must teach the subjects in his own way.

He cannot confine himself absolutely to the subject which the professor of engineering says he wants his students to know. The professor of mathematics must decide what is to be taught, and he can do this if he has obtained all the information possible from the engineering professors, bearing in mind all the time that he is teaching students in an engineering college. These two departments should work together in this way.

I do not believe that it is possible for the department of mathematics to show the students how to apply mathematics to specific engineering problems, except in the most elementary way. This has been a disputed point for many years between the mathematicians and the engineers—at least, between some of the engineers and some of the mathematicians. And some professors of engineering have claimed that the mathematical work in their institutions was not thorough enough, because the students were not able to handle mathematics in the engineering department. The case is somewhat similar to that of the student who begins analytical geometry. He has learned how to handle the ordinary processes in algebra, and he knows how to make the transpositions, etc. But when he is told that he must give a geometrical meaning to every algebraic equation, it is new and difficult for him at first. That however is

a part of mathematics and the professor of mathematics must overcome the difficulty. But when a similar problem comes up in civil or electrical engineering, or in one of the many parts of mechanics, it seems to me that the work must be done by the professor of engineering or mechanics, and not by the professor of pure mathematics. In order to teach these practical problems to the student, one must teach him more or less of the engineering subjects, which will require a much longer time than is now given to the subject of pure mathematics in most of our engineering colleges.

PROFESSOR FLETCHER: The speaker is in entire accord with Professor Howe on this matter, believing that mathematics should be taught as mathematics, and applied to engineering when the student takes up engineering and begins to master the definitions and applications which are distinctively problems of engineering. But it would be a very good plan for either the professor of mathematics, or some representative of the engineering departments to give the students, at the proper point in their mathematical studies, a résumé of the applications of mathematics. For instance, an engineer might indicate the uses of the theory of the higher curves and other geometrical principles and the more common applications of analytic geometry and calculus in structural and mechanical engineering, to kinematics, etc. The students would thus become interested in the subject, and for that reason it would be a great advantage for them to be enlightened in advance. It is difficult to decide how best this can be done, and at what time in the course it should be done. But we will all agree that a great many men begin mathematics and go through it with very little idea of what they are driving at. They begin to appreciate the utility of it only when they come to their engineering studies. They then find that they have wasted a great deal of time, and could have learned a great deal more and appreciated it much better had they been told of these things in advance.

PROFESSOR WILLISTON: Mr. Chairman, I am pleased with the increasing emphasis that has been placed upon the simple

fundamental mathematical principles and with the tendency to decrease their number to that of the essential basic ideas. This will help us a great deal in working out this important problem. It is important because the teaching of mathematics to engineering students involves not only that subject, but also the most important of all technical subjects, pedagogy, which is at the base of all technical instruction.

There are one or two matters that have not been emphasized in the discussion this afternoon. We all agree, undoubtedly, with Professor Howe, that a professor of mathematics cannot be expected to be a professor in all fields of engineering, able to show the application of the basic principles of mathematics to this or that branch of engineering. Nevertheless, I am convinced that one of his most essential functions is to show the application of these principles to *something* in engineering and to do it constantly. The principles, appearing simply as abstract propositions, are not what engineers need. They need basic principles to use, and one of their requirements is the process of using them. It is not necessary to go into the advanced fields of engineering to find illustrative material. In elementary physics there is abundant material with which to apply the principles.

Finally, I believe in connection with the teaching of the principles of mathematics and of mechanics, that numerical applications should be made continually. Let me give an illustration to show the necessity of this. In the course of the year I interview many prospective teachers, applicants for positions either in mathematics or applied science. If they tell me that they have taken advanced courses in mathematics and have made a specialty of mathematics, I usually give them a simple problem, to find the area of a triangle. I never find a man who can put the limits in right. They do not know how to do it. On the other hand, they can go through the process of integration of almost any formula, but when it comes to determining by means of that formula the area of a triangle, they cannot do it. The question is, therefore, not so much what shall be included, as it is what is the best way of

making the teaching concrete. For men who are to deal all their lives with practical problems, and who must obtain concrete results from concrete data, the importance of this cannot be overestimated. I also place a great deal of importance upon the application of the principles by the students, in order to help them become familiar with some of the things that the professors of engineering will want them to know later.

THE PRESIDENT: A great deal of difficulty arises from the use of inexperienced instructors in this, as well as in all other lines of work; men who do not know how to teach. The theory of teaching has its value, and the young instructor can learn a great deal by studying the methods of older men.

PROFESSOR HUNTINGTON: It seems to me desirable that there should be a classification of engineering problems of a mathematical nature according to the mathematical principles and methods employed in their solution; this would be a suitable topic for a master's thesis.

PROFESSOR V. KARAPETOFF (by letter): The writer gave at Cornell in 1908-9 a course in "Engineering Calculations," for seniors in engineering courses. The course consisted of two recitations per week throughout the year and of problems to be worked out at home; Perry's "Calculus for Engineers" was used as a text-book, supplemented by various extra problems. The work comprised mainly applications of calculus and analytic geometry to the solution of problems taken from mechanical, civil and electrical engineering. The following are some of the conclusions to which the writer came, at the end of the year:

1. There should be a place for such a course in the senior year of every engineering college, but the course must be strictly elective, for those mathematically inclined. There always are a few students whose mathematical talent in application to engineering problems remains dormant without such a stimulus.

2. The principal emphasis must be laid upon the reasoning by which engineering problems are clothed in a mathematical form, and not upon routine mathematical operations and

transformations. Experience showed that as soon as the students began to feel ground under their feet they referred to their old books and notes for purely mathematical rules.

3. The idea of coöperation and division of labor with pure mathematicians must be maintained all the time. The students must understand that an expert in pure mathematics may not be able to solve an engineering problem until it is reduced to his language; but after this has been done, he may be able to indicate a simpler and a better solution than can an engineer, who handles such problems only occasionally.

4. The student must be made familiar with time and labor-saving methods, such as plotting to a logarithmic scale; expanding into a series for numerical calculations, or integration; graphical and approximate solutions of equations; the use of all kinds of tables, etc. In this connection the writer wishes to mention the following books which he has found useful: Peirce, "A Short Table of Integrals"; Seaver, "Mathematical Handbook"; Saxelby, "Practical Mathematics"; Castle, "Practical Mathematics."

5. Many engineering problems involve more than one independent variable; therefore, a considerable amount of time was spent in solving problems involving the use of partial derivatives in analytic treatment, and of surfaces in graphical treatment. Very little trouble was experienced in these matters as soon as the students understood their practical significance. Two large metal models were constructed to facilitate the understanding of the subject. One model showed the surface $pv = RT$, corresponding to the characteristic equation of the perfect gas. The other illustrated the general relation between partial derivatives and the complete differential. The writer hopes to publish a complete description of these models later on.

6. All problems must be carried to their final practical consequences and numerical results. The student must see the import of the solution and the fact that it could not be arrived at in any simpler "common sense," or "rule of thumb" manner. The influence of fundamental assumptions and of ex-

perimental coefficients must be emphasized, and no results should be allowed to stand without analyzing the practical limits of their validity and accuracy. As a prominent French engineer, Dupuit, has well said: "Formulæ are but tools which may guide intelligence, but can never replace it."

7. In his search for suitable problems the writer went through numerous American and foreign books and periodicals on machine design, structural mechanics, resistance of materials, hydraulics, thermodynamics, and electrical engineering. He expects to publish a collection of such problems with solutions, hoping that it may facilitate the work of teachers of higher mathematics for engineers.

In conclusion, the writer wishes to make the following recommendations with respect to teaching pure and applied mathematics in engineering colleges:

A. The course must be made continuous throughout the four or five years, and not concentrated during the freshman and sophomore years, as is done now.

B. Engineering applications should be given throughout the course. The course should be taught, at least during the first two years, by a person who has had engineering training, or is markedly inclined towards applied mathematics.*

C. The following courses in mathematics, in application to a five-year course, are suggested: first year, applications of elementary mathematics to engineering; second year, introduction to analytics and calculus, limited to engineering applications; third year, elementary analytics and calculus; fourth year, advanced analytics and calculus; fifth year, elective studies in higher mathematics, and in mathematical physics and mechanics.

This schedule is taken from the table in the writer's paper, "On the Concentric Method of Education in Engineering," presented before the Detroit meeting of the Society in 1908.

* In arithmetic most problems are taken from life and commerce; why should not the problems in calculus be taken from man's future profession, instead of being meaningless exercises in abstract ingenuity?

HIGHWAY ENGINEERING.

BY MR. L. W. PAGE,

Director of the Office of Public Roads, United States Department of
Agriculture.

In no other field of governmental activity in the United States, whether the unit of government be the township, the county, the state or the nation, has the lack of skilled supervision been so marked as in the building and maintenance of the public roads. There are to-day more than 100,000 petty road officials in the United States, comparatively few of whom possess an adequate knowledge of road building.

There were at the close of the year 1904, 2,151,000 miles of road in the United States of which less than 39,000 miles were surfaced with stone, and less than 154,000 miles with gravel, although the expenditures aggregated about \$80,000,000 per annum in money and labor, or about \$1.05 for each inhabitant. These figures give color to the claim that half of our road revenues are wasted.

Within a period of eighteen years, however, a change has taken place in our systems of road administration—a change which involves substitution of centralization for localization in road work, the elimination of statute labor, a large increase in cash road revenues, a general and more continuous system of maintenance, and a more practical and business-like administration in this whole field of public activity.

State participation in road building and maintenance, beginning in 1891, is now accepted either in practice or principle by nearly half of the states, and every change in the road laws of these states has been towards a broadening of the scope and authority of the state highway departments and increased state appropriations for this purpose. Other states are actively considering the matter, and it is now apparent to all students of the subject that it is only a question of time

when every state will have adopted the state aid and supervision plan.

The success of these reforms rests upon the ability of the states to obtain an adequate number of men qualified to direct properly the building and maintenance of the public roads.

The commerce of the country demands better highways, and these can be secured only by skilled supervision. If for any reason the supply of highway engineers is insufficient to meet the demand, disastrous results must ensue. Not only would this mean large financial losses, but failure at this stage of the progress would undoubtedly result in a reaction of public sentiment, which would retard the development of road building in the United States possibly for many years.

This brings the question fairly and squarely before the educational institutions of this country. If sufficient highway engineers are not available it is because the educational institutions have not grasped the significance of this great movement for better highways, and have failed to make adequate provision for broadening the scope of this branch of engineering. I believe that this is partly the case, and I take the liberty of submitting for your consideration the results of an investigation which I conducted in March of this year, through the U. S. Office of Public Roads, on this subject.

A circular letter was sent out containing three questions, to ascertain the status of highway engineering, the plans for improvement, and possible line of coöperation between engineering schools and the Office of Public Roads. Replies to about 70 per cent. of these letters have been received, and of this number about 50 per cent. indicate no course in highway engineering. Of the 50 per cent. who do have such courses, one third indicate their intention to extend them, one third not to extend them, and one third were non-committal. Of the 50 per cent. who have no courses, 15 per cent. indicate their intention to establish them as opportunity presents itself, or as soon as demand is forthcoming for such a course.

The method of instruction is divided between lectures and

class-room work, with a balance probably in favor of the class-room. One school gives 8 lectures, another 27 and proposes to add 3 more on the subject of county highway bridges during the coming year. Others indicate that part of the instruction is by lecture.

The amount of class-room work, or time allotted to highway engineering in different institutions, is stated as: 2 hours per week for 16 weeks; 2 hours per week for 1 term; 2 hours per week for 14 weeks; 3 distinct courses; 3 hours per week for 1 term; 5 hours per week; 2 hours per week for 1 term; 5 hours for 5 weeks; 4 hours per week for 2 months; 1 hour per week for one term, 25 to 35.

Text-books used are Baker, Byrne, Morrison, Richardson, Spaulding, and publications of the Office of Public Roads.

Less than one-fifth of the schools giving a course in highway engineering have a laboratory in which tests are made of road building materials, and less than one-eighth indicate that any work is done making surveys or plans for highway improvement. Among the last number is one school that requires each student to make plans, profile, cross-sections, and estimate for five miles of improved highway, data for same being taken from the topographic sheets of the U. S. Geological Survey.

No schools are considering the question of dust preventives and less than 10 per cent. indicate that attention is given to road economics.

Fifty per cent. of those replying requested information that would aid them in establishing laboratories for the practical testing of road materials or otherwise improving their courses to better meet the present demands. Twelve schools have requested that a lecturer be sent during their course from the Office of Public Roads to give one or more illustrated lectures on the subject of highway construction.

Road building is an art based upon a science, and it is necessary that this be borne in mind in evolving any plan for improvement in existing courses of instruction. It is the province of the educational institutions, it seems to me, to provide

adequately for instruction in the principles of engineering applicable to road building, and to give their moral support and influence toward obtaining for the students the actual practice of road building outside of the college, which is so essential to the acquirement of the art of road building.

The suggestions which I have to offer will apply, therefore, first, to the instruction given in the college, second, to the activity of the college outside of this sphere.

I would first suggest that a more thorough course of instruction in highway surveying be given, and that each student should be required to prepare profiles, plans, cross-sections and estimates for a sufficient length of road to familiarize him thoroughly with this branch of the work. In this connection, I call your attention to the fact that less than one eighth of the colleges replying to our inquiry now require students to perform such work.

An elementary course in geology should form part of the instruction of every student in highway engineering, so as to enable him to become familiar with the appearance, characteristics and nature of occurrences of all the more commonly used road materials. It is not uncommon for an engineer to take up the work of road building with absolutely no knowledge of road materials.

Modern traffic conditions are such that the building of practically dustless roads in the vicinity of all great centers of population has become necessary. This involves the general use of bituminous and other binders, and it is essential that the colleges give such instruction to the student in highway engineering as will equip him with a sufficiently accurate knowledge of these materials to understand properly specifications for roads of this character.

I desire also to impress upon you the importance of devoting greater attention to the study of road economics, for the reason that the average highway engineer in most cases becomes a public official charged with administrative duties involving large expenditures of money.

The practical experience in the building of roads which the

student should have before beginning the practice of his profession must be obtained outside of the college. This instruction the Office of Public Roads has been endeavoring to supply to a limited number of graduates in civil engineering during the past four years. The plan under which we have been operating provides for annual competitive examinations to which graduates and members of the senior classes in civil engineering are admitted. From the register thus obtained, appointments are made at a salary of \$60 per month and field expenses. These students are given thorough training in the laboratory, and are then sent to the field and given practical training in all branches of road construction, including the making of surveys, the preparation of plans, cross-sections, estimates and specifications, the operation of machinery, and the supervision of various branches of the work. During the months of January and February of each year, they are called in to Washington and are given a scheduled course of theoretical and practical instruction, which includes a study of bitumens, clays, asphalts and cements, the chemical and petrographic analyses and physical tests of all road materials, the study of road legislation and administration, library research, plotting, planning, computing, estimating, problems, checking reports, computation of unit costs and the preparation of cost data. They are required to prepare papers dealing with various phases of road work, and to read and discuss them at meetings and to prepare in addition a thesis covering some particular branch of the year's study. In all twenty-three students have been appointed.

I realize that this plan will provide but a small percentage of the engineers which will be required. Nearly half of the states now have state highway departments, however, and I would suggest that the college authorities arrange with these highway departments for the employment of students in highway engineering during the summer months, at a nominal salary. In this way, the highway departments would secure competent assistants for a small outlay; the colleges would then supplement their regular courses, and the student would

obtain the training which is essential for him before he undertakes work on his own responsibility.

Beyond this point, the Office of Public Roads will afford every facility for additional engineering students to receive instruction both in the laboratory and in the field, but no compensation can be paid.

DISCUSSION.

THE PRESIDENT: The meeting is now open for consideration and discussion of the paper just read by Mr. Page. As there is great variety of practice in highway construction we shall be interested to hear comments on this paper.

MR. WILEY: I do not know much about highway construction, but I was in the State of Rhode Island recently and I had an opportunity to make a tour of inspection with some of the officials of that state. One was a professor in Brown University; another, the Superintendent of Streets of Brookline, Mass.; another, the Superintendent of Streets of Newton, Mass. We inspected in Providence a bituminous macadam which had been submitted to very heavy traffic, of automobiles and drays. During last winter, a comparatively open one, it was subjected to sharp-shod horse traffic. Next, we examined in the Charleston district, beyond Narragansett Pier, a bituminous macadam road which had only been subjected to a very light dray traffic and considerable automobile traffic. That bituminous macadam had been in place for three years, and, where the instructions of the superintendent of roads had been completely followed, it seemed to show very little wear. I speak of this because the highway engineer had a laboratory and many of the students in the laboratory were competent to supervise the building of roads, and to suggest such improvements and changes as the laboratory experiments showed to be desirable. The superintendents of streets were very much interested in what the professor in the party had to say. The professor, in turn, was interested in learning the result of their experience in actual work. This shows the co-operation which exists between the practical man and the

student. We are, as Mr. Page has said, very much interested in getting a good dustless road. With the supply of cheaper asphalt mixtures we are likely to get a good bituminous macadam road, at not very much more expense than the ordinary old-fashioned macadam road. This is a good business proposition as our automobilists are generally our best taxpayers.

MR. PAGE: Mr. Wiley probably refers to the work of Mr. Blanchard, who is doing such excellent work with his students. He is building most excellent roads in the State of Rhode Island.

There is a rather new material which promises to be an excellent dust layer. This is the refuse sulphite liquor of the pulp mills which has been turned into our rivers, polluting them and killing the fish. I recently made an experiment with this material in road building. By simply sprinkling it on a macadam road surface I succeeded in getting a road through which a pick could scarcely be driven. It is perfectly dustless.

PROFESSOR ALLEN: It is interesting in observing the development of highway work to note that those who a few years ago understood the construction of macadam roads were in a good position to teach highway engineering. In the last few years the development has been largely in the coatings for fixing the dust and the macadam material, so that those who formerly knew all about highways may know almost nothing useful to-day. They are entirely out of line unless they have kept in touch with these new matters.

After a recent meeting of the Massachusetts Highway Association, I had occasion to state that the old-time builders of macadam roads are entirely out of line. The superintendents referred to by Mr. Wiley subscribed to that most fully. I repeat, therefore, that there has been a very great change, and unless the people who are teaching highway engineering keep up with these new developments, they certainly must be very inefficient.

MR. PAGE: The present condition in highway engineering

described by Professor Allen is an abnormal one. The activity along this line of work for the past few years has been tremendous, and the state appropriations have grown correspondingly. For example, the State of New York has appropriated fifty-five million dollars to be spent on highways, and one county (Los Angeles, California) has appropriated three million and a half dollars. Santiago County is just about to appropriate a million and a quarter. Experienced highway engineers are, therefore, in demand. This condition will be met in fifteen years probably, but there are not enough experienced highway engineers at the present time.

I will state, further, that the salary of the highway engineer is now very good indeed. One of the first men who took the course that I have described remained with us just one year after completing the course. I then secured for him a position as chief engineer of Los Angeles County, Cal. at a salary of forty-five hundred dollars a year. He received fifteen hundred dollars while with us. Letters come, almost every week, with requests for experienced highway engineers for important work. I cannot get them, for they all have good positions.

PROFESSOR ALLEN: The position that applied chemistry has taken as a branch of engineering is not confined to highway engineering, but is found in other branches as well. The study of highway materials is a branch of applied chemistry, even more perhaps, than it is of engineering; and I am not sure but that sometime in the future, instruction in materials will be given by chemists rather than by engineers.

PROFESSOR EMORY: Will Mr. Page kindly tell us whether the dry scraper or the old-fashioned road machine is the better? Also, has any action been taken by his department to extend a knowledge of the necessity for the use of wide tires?

MR. PAGE: We are doing a great deal toward disseminating information in regard to building the "drag" that has just been referred to. I still employ the man who designed the first drag, Mr. D. Ward King. I have sent him about to

address meetings of farmers, county commissioners and road overseers, and to lecture and demonstrate the method of building as well as using the drag. I have several other men who have become expert with it. It is the best and cheapest form of maintaining an earth road that I know of, far better than the road machine. I have photographs of two adjacent sections of road in Mississippi, one crowned with a road-scraper, the other with a road drag. And last fall, I had photographs taken of the two, from the dividing line, in each direction. The photographs show that the road crowned with a drag was in excellent condition. The other was a perfect "slough of despond."

MR. EMORY: Have you any data relative to the cost of operating the drag as compared with that of the road machine?

MR. PAGE: I do not believe that there is much difference in cost. The original cost of a road machine is not very great, but the drag can be built by any wheelwright for two or three dollars. If it is operated properly, it can be driven eight or ten miles a day.

We have not had much to say about the use of broad tires. The whole problem is to improve the roads so that any tire will operate upon them. Last summer we made a series of tests with a light road wagon which could be equipped with eight different types and widths of tires. We hope to publish the data from these tests very shortly. However, the best plan is to build a road that will stand any ordinary width of tire.

PROFESSOR ALLEN: Some years ago this was a very urgent question before the Massachusetts Highway Commission. One point of view, perhaps the controlling point of view, which they took, and which prevented their recommending any legislation was this: that on fairly good roads a wide-tired vehicle undoubtedly improves the road, but when a road becomes poor and vehicles sink to the hub, it is somewhat more troublesome to extricate the wide-tired wheel than the narrow-tired wheel. When the road exceeds a certain degree of inferiority, the wide tire is probably a disadvantage. In Massachusetts they have decided to leave the matter alone.

THE PRESIDENT: This is one of the most interesting examples of how changes in the science and practice of one branch of engineering are brought about through the development of some related art. The automobile has upset all of our old theories of road-building, until now we know scarcely anything about the subject, and have to begin all over again. This fact should interest particularly the schools supported by the state, especially in those states where large public expenditures for public roads are contemplated. It is a line of study well worth the best thought of those who are teaching and studying in that department.

THE RELATION OF ENGINEERING EDUCATION TO INDUSTRIES.

BY MR. CHARLES BUXTON GOING,
Managing Editor, *The Engineering Magazine*.

Engineering is peculiarly a progressive profession. Its practice demands constant improvement in controlling natural forces for material advantage. Its principles are fixed, but their application is mutable, and in following the constantly growing number of applications the history of engineering has become one of constant expansion, the development of theory affording an ever wider and wider circle of contact with practical applications, until now there is practically no phase of our industrial system, of our social organization, even of our domestic occupations, which does not rest at some point upon the work of the engineer.

This new and highly vigorous enlargement of the scope and functions of the engineer began with that well-known group of inventions introducing the factory era. In these dynamic applications was inherent a vigor of swift and many-branched evolution destined to change the face of civilization more in a hundred years than the older works of static engineering had changed it in many hundred. No force so pervasive, so insistent on constant progress in production and in efficiency of production, could be introduced into society without altering profoundly its outward form and its ideals. The daily routine, the home surroundings, the food, clothing, the occupations open and the experiences accruing to every individual, were widely changed by the new order. The things society now demands of the man and the things a man now demands of society are quite unlike those known to our great grandfathers. And no change so universal, so intrusive, could fail to affect an institution as vitally interwoven with the social fabric as education. Even that most conservative and slowly

changing of all concepts and orders—the ecclesiastical—had to yield much to the scientific mode of thought; and educational institutions, by tradition associated intimately with the clerical establishment, and only slightly less reluctant to admit change or revision, were forced to defer to new ideas of what a man should be expected to do and how he should be prepared to do it.

The movement made its influence felt in the courses in the classics, arts, and letters; but its most emphatic expression was found in the foundation, the growth, and the progressive specialization of the schools of applied science. Here it appeared in its full measure, as a secession which has not yet been accepted with entire toleration nor admitted to complete fellowship by the old-school academicians. This new educational ideal, indeed, is as revolutionary as that which has found expression in the material civilization of our day—the ideal of an education which is both liberal and practical. The older objective of the well-read scholar has given place to the newer one of the scholarly worker. The new professional schools proposed to displace the classics in favor of the applied sciences, but still to afford cultural education as well as utilitarian instruction. In place of the subjective, analytic type of mind active chiefly in the realm of philosophy and letters, fostered by the older system, they aimed at the development of an objective, synthetic mentality, creative in the sphere of material things. A new order of civilization was demanding a new educated class. Education was being brought back to closer touch with the most vital interests of the spirit of the times.

But the inherent tendency of all human systems, whether they be of religion, art, letters, or science, is to crystallize. The history of thought, in every domain, is a recurrent cycle of hardening creeds broken through from time to time by a new outpouring of protesting revolution; and the reformer of yesterday becomes in his turn the formalist of to-day. Our schools of applied science have been—and are—so splendid in their achievements that criticism is ungrateful, and may seem

captious; but if it must be offered, it would seem to be that they, in turn, are over-academic. The prevalent belief that the engineering graduate is "too full of theory"—that he must have a considerable supplementary training in minor "practical" positions before he can be trusted to work out results which will be economically valuable—would seem to indicate that his training has failed to include recognition of some important elements in the problems he is supposed to have been taught to solve. For the shortcoming suspected is not simply his comparative inexperience. There are no back stairs to the treasury of knowledge gathered through years of contact with all kinds of undertakings under all kinds of conditions, and nobody expects the technical schools to discover, or to build any. The fear is not as to the height or elaboration of the structure of the education they afford, but as to the inclusive scope of its foundations and as to its perspective. The belief, in short, is that the school is out of close parallel with life.

I realize most clearly that any such criticism as I have just offered can apparently be immediately disposed of by citation from the catalogue of almost any large engineering school. The number and diversity of courses that may be found therein would seem to indicate a close observance of almost all the ramifications of engineering work and the survey and construction of an educational pathway closely following each. What, then, is the meaning of the criticism which I have implied? It is qualitative rather than quantitative. To put it baldly, it is that the subjects all too often are not taught as they must be practiced.

For this condition, if it exists, I think there may be two main causes. The first is, the persistence of the natural tendency to cling to old forms and methods of education or to change them as little as possible in applying them to new subject matters. That is the way in which the world usually introduces its great changes, even changes which are destined ultimately to prove revolutionary. The first railway carriage was a sort of glorified stage-coach body hung on a new style

of wheels. It took two thirds of a century to evolve the Pullman coach, the air brake and the M. C. B. coupler. Steam at sea did not venture to discard spars and sailing-vessel lines, nor to commit itself to hulls designed properly for screw propulsion, until after nearly a half-century of experiment. Up to the time of our Civil War and even later, the battleship differed from the merchantman chiefly in the number of decks and guns with which it was equipped; a little more than a quarter century has covered the specialization of the battleship as a wholly distinct genus. The university (which, as I have already suggested, clings to traditions even more closely than sea-faring folk) has not yet had as long as this to adapt its form and structure to the new power by which it is actuated. I do not know what the technical school of 1950 may be, but I venture to think that it may differ organically and functionally from the technical school of to-day, more than Columbia School of Mines and the Massachusetts Tech differ from Oxford and Cambridge of 1850.

Now, most unfortunately, so far at least as concerns university teaching of a subject like engineering, the good old academic temper has always been fearful, if not intolerant, of anything utilitarian—or, to use frankly the more objectionable word, of anything commercial. It is traditional that a German professor has been known to thank God that no one could by any possibility ever make any use of his subject. I, personally, heard the German-trained incumbent of a teaching chair deplore the wretched necessity of having any students at all at the university; it interfered so with the professor's opportunities for research and meditation. If my observation and interpretation of phenomena are correct, some lingering vestiges of this old mood (a fine one in its own proper place, but now persisting out of place) have made our technical schools reluctant to recognize and to teach economic limitations as clearly as scientific standards of perfection. It has been said that anything is feasible in engineering if it is within the laws of nature; the question whether it is advisable is determined by the law of dividends. The engineer, whose

function it is to carry works of construction or production to practical success, ought to be competent to plot accurately the curve along which the forces behind these two systems of law are in equilibrium; the complaint is that his schools give him too academic a devotion to the one and an inadequate idea of the imperative character of the other. Theoretical standards of construction and theoretical figures of performance are idealized in his philosophy, and the ideals are not sufficiently balanced by a knowledge and appreciation of costs, and of the fact that there is always a point, varying with every case, beyond which further refinement toward the ideal spends more than it saves and so becomes a vanity of perfection—a professional mistake.

It is not for a moment desirable that the vision of the goal set by pure science be obscured, but only that the understanding be increased of the approximations which it is expedient to accept in actual performance, and the conditions by which they are determined. For illustration: the development of the steam engine from Savery's "miner's friend" to the modern Corliss, or (say) the engines of Inchmarlo, is a wonderful exhibition of improvement in efficiency in which the data of thermodynamics have been the inspiring and directing influence. Everyone must wish the student of mechanical engineering to possess sufficient knowledge of the science to understand what has been done and to take an intelligent part, if necessary, in continuing it. But the choice of a power plant in any given case depends on a careful comparison of the net total of interest on investment, expense of maintenance, depreciation, wages of skilled attendance, and fuel costs. It may easily be proven that—in a Pennsylvania coal mine, for example—a plain slide-valve machine, wasteful of coal but cheap and easily run, will be most serviceable to its owners. The average graduate is many times more likely to meet the need of advising as to such an installation than he is to find opportunity for further betterments in steam-engine design; but is he one-fourth as well-informed in the conditions of commercial efficiency as he is in thermo-dynamics?

Or again: the design of a piece of machinery may require a sound, scientific knowledge of mechanics and kinematics, a careful mathematical calculation of stresses and weights, and a high degree of skill at the drawing board. But if cost of construction is important—and it usually is very essential—it requires also attention to economy in the use of the material, and especially of the labor, involved in manufacture; the selection of stock sizes; the standardization of gears, arbors, bores, tapers, bolts and screws; avoidance of difficult problems in pattern making and moulding, and minimization of labor in machining and assembling of parts. Does the average course impress the student with these common-sense considerations in the handling of materials as strongly as it does with theoretical mechanics or the technique of draftsmanship? Can it possibly do so, until the economics of engineering are given an entity in the curriculum, and made to occupy an arc of the educational horizon as large as that which they will fill in the graduate's discovery of his life work?

Yet the very analogies I have cited would prove that the evolution of the scientific school to exact adaptation to its environment would proceed with reasonable rapidity were it not for the second obstructive influence at which I have hinted. This is the jealousy of the universities which makes them debar the members of their faculties from mingling in practical affairs. The situation becomes like that which might result if the merchant-marine companies or the Navy Department discouraged their deck officers from familiarizing themselves with the use of steam.

While the colleges have been unable to offer rewards large enough to compensate an able specialist for resigning independent work in his profession, they have discountenanced or discouraged his combining outside practice with university service. It is vastly to the credit of our professors that in spite of this disadvantage they have maintained so active and earnest an interest in all contemporary developments; but without the competitive participation and the daily intercourse that constantly sharpens the edge of the consulting engineer's knowl-

edge, the college man is almost of necessity prevented from maintaining more than an academic familiarity with the broad range of subjects he is expected to teach. His assistants, further, upon whom the students must depend chiefly for personal instruction and individual contact with their technical work, are usually drawn—and by budget necessity must be drawn—from a class of men whose experience outside of university bounds is scarcely a step in advance of that of the undergraduates themselves.

The internal influence of staff, therefore, which has done so much to aid the evolution of the steamship, and notably of the battleship, is distinctly weak in the practical evolution of the university. Immersed in an academic atmosphere, the technical teacher tends to become more academic; and so the tone, reflected back and forth between like media, deepens in intensity.

I trust that no one will take these expressions of personal opinion unkindly or think that they are meant unkindly. I am one of the family, and I am not speaking in the third person, nor in the second, but in the first. I am not talking about “them” nor about “you,” but about “us.” Indeed, influences exactly like those I have been describing exist in technical editorial offices as largely perhaps as in universities, and as I am both a technical editor and a member of a college faculty, I must be doubly dyed in the same tincture.

Now, criticism which is not constructive fulfills only half a function. Let me attempt the dangerous service of suggestion. A traditional institution of the universities is the professor’s sabbatical year, in which he is supposed to travel and to familiarize himself with the work done in his subject elsewhere. Suppose that, recognizing the relatively high rate of progress in the applied sciences, these sabbatical periods in the technical faculties were reduced to five years, or, better still, to three; and that the teacher were required to spend each third or fifth year *not* in sojourning at other universities, working in other laboratories, hearing other lectures, and seeing how this subject is *taught*—but in active work as an

official or *attaché* in a railway organization, a bridge or construction company, or a manufacturing plant, seeing how the things he teaches are actually *practiced*. Salary would be immaterial, as his full income from the university would be continued; opportunity for the widest and closest possible contact with work in the field under "all the conditions there are" would be everything. I owe the completion of this concept to the active executive manager of one of our largest manufacturing corporations. His enthusiastic approval of it goes far to indicate the cordial coöperation that would be given by business interests in making such a plan operative. To them it would bring not only the valuable aid of the university man's trained faculties, but the prestige of association with colleges of high standing and repute. To them, also, would soon accrue another advantage in the higher usefulness of the graduates turned out from the college to enter industrial or engineering service. To the professor would be opened the most fertile and most instructive working and research laboratories, where experiments on a full-sized scale, backed by an endowment such as he never could dream of controlling, were spread before him in full operation twenty-four hours of the day. And think of the assured grasp of the latest ideas and methods, the freshness of viewpoint, and the energy of demonstration with which each man would return to his classes after a year in the field. This would be a sort of university extension that would keep engineering education and engineering practice in intimate communion and in constant parallel.

To illustrate and exemplify the results of uncorrected academic tendencies by specific example, let me present an instance, at which I have hinted several times with increasing insistency. The factory is surely no less characteristic and no less fertile a department of the industrial era than the railroad or the steamship. It employs, probably, a larger number of technical graduates than stationary, locomotive, or marine engineering, and the proportion is increasing. But while institutions so conservative even as the Lords of the Admiralty and the Navy Department have realized that the modern

warship is a huge, coherent and interlocking, sea-going and power-driven fighting machine, and that it must be officered by engineers trained in seamanship and navigation, steam engineering and hydraulics, electricity, ordnance, sanitation, discipline, language and international law, our technical faculties seem to have been less responsive in their sphere. The civil engineering college has been very slow to recognize the factory as a vast, coördinated manufacturing machine, demanding a personnel instructed not merely in dynamic engineering, but in executive organization and management, economical works design and construction, transportation and handling appliances, tool-room practice, stores-keeping, wage systems, time records, shop discipline and sanitation, and by no means least, cost analysis and study.

Columbia has now struck out boldly on a new policy, introducing courses on works management, works design, shop transportation, and handling of materials, conducted by specialists in active practice who bring into the lecture room the atmosphere and viewpoint of actual professional life. Indeed, within their powers, the chairs most closely allied to the subject in several universities have tried to incorporate at least some of these elements in their scheme of work and lectures. Worcester makes an interesting and praiseworthy exhibition of manufacturing conditions as nearly as they can be reproduced in the school shop. Stevens shows a lively appreciation of the business elements in engineering work, and of the necessity that the technical graduate shall perceive them. Harvard has launched a school of business administration of comprehensive scope but not as a part of the engineering faculty. The Cincinnati experiment may also be referred to, and there are other partial instances deserving high credit. But the field is too large to be cultivated adequately with the facilities usually afforded. The effort of the mechanical department to compass it to-day is something like that which an earnest and conscientious professor of physics twenty-five years ago might have shown in trying to keep firm and controlling grasp on the rapid development of electricity.

I have been tempted to expand this point of current criticism upon the technical curriculum because just here the difference is most discernible between the preparation which the school gives and the equipment which the work of the graduate demands. The difference again is not so much quantitative as qualitative. For if in theoretical training the courses of instruction lean too strongly toward pure science, in shop training they lean too far toward the handicrafts. The aim (to illustrate by an intentional exaggeration) seems to be to turn out a composite of the natural philosopher and the mechanic—a sort of scientist in overalls. Now it is not manual training, however glorified, that is needed, but a trained observation of, and a capacity to measure, the forces and factors entering into production or construction, under competitive commercial conditions.

In so far as any lack of proportion or of balance may exist in the resultant of the present technical courses, it is probably due to a disposition so admirable that one hesitates to call it a defect—that is, the passion for thoroughness actuating every member of the faculty, each in his department. The director of the college work shops is unwilling that the pupil shall begin anywhere above the bottom, and the professor of mathematics is insistent that he shall stop nowhere short of the top. As a result, the student seeking a profession invades a trade at one end and a pure science at the other. As another result, the term is so crowded that lectures, demonstrations, laboratory work, the drafting room, the field, clamor and all but clash in demand for the students' time; and when any new scheme is proposed—engineering economics, for instance—the first exclamation is always, "How can you possibly get it in? Our courses are far too full already!"

But, after all, I do not know that what we teach is so important as how we teach it. The question is not so much of the functional performance of our engineering schools as of their organic constitution. Are we doing the best that can be done, or all that should be done, to establish right relations between the faculty and the profession and between the student and

the faculty, or to introduce the student to the atmosphere, the viewpoint, the fundamental attitude and spirit of his life-work? Let me revert for comparison to an illustration I referred to awhile ago—the methods of the navy or of the war department. Perhaps because the fighting men were always a distinct caste, largely freed from the traditions of the priestly order, the military or naval student is treated in a wholly different manner from the college man who was originally a disciple of the clergy. The cadet is placed at once in an environment as nearly as possible like that in which the line officer is to work. He is given a daily routine, placed in an attitude toward his instructors, held to discipline and exercised in operations, as nearly as possible identical with those under which he will live and amid which he will rise from grade to grade. Class-room work is tributary to physical training, the parade ground, the camp, the field and the cruise.

But although engineering, whether static or dynamic, demands organization more nearly like the military form than any other civil occupation, our engineering courses try to mold men for this most active and energetic pursuit by methods inherited from the cloister and the cell. We make laboratory, shop and field scarcely more than an annex to lecture-room and study. We assume to a very large extent that a system excellent for teaching theology, the classics, letters, and perhaps pure mathematics, will serve for teaching railway engineering, superintendence of a power-plant, or shop administration, by the mere change of text-books and of topics discoursed upon from the lectures' platform. We attempt to develop that "objective, synthetic" habit of mind of which I spoke some time ago by a mode of training evolved to reach the ideal of a subjective, analytical mentality. It takes our students some years of after training to learn to be something more than analytical and critical and to get down to do things.

In short, the boy entering Annapolis or West Point steps at once into the life of the navy or the army and becomes a

part of it. His graduation is merely a step forward in the same direction. The boy entering one of our engineering schools usually steps into something totally *unlike* an engineering corps, a manufacturing shop, or the motive-power department of a railway. His graduation is a plunge into a strange and bewildering stream moving in a new direction, in which he must find a new foothold and new orientation.

The change, therefore, that I think will bring us nearer to truth is not one of detail; it is fundamental. It can not be accomplished easily. Nevertheless, somewhere in that direction, I think, lies the way to the great technical school of the future. We shall begin to work towards it when we devise some plan by which our engineering teachers will live nearer to our practicing engineers. We will grow nearer to it when, in our schools of applied science, a closer fellowship is established between "town and gown." The jealousy of many universities, which discourages the teacher from maintaining close touch with active professional work, as already suggested, is one of the regrettable influences forcing our practical science courses out of parallel with the progress of industry. A more weighty one still, perhaps, is the small opportunity given the alumnus to be heard in university councils and to bring back within university bounds the fresh spirit and suggestion of the constantly changing world without. The result is an inevitable set toward formalism and scholasticism on one side, and toward apathy on the other. Through freer, wider, and more frequent intercourse between faculty and alumni, probably more effectually than in any other way, will the evolutionary forces of the wonderful system of technical education be kept fresh, vigorous, and instantly responsive to the demands of industrial life.

WHY MANUFACTURERS DISLIKE COLLEGE STUDENTS.*

BY MR. FREDERICK W. TAYLOR.

The educational question interests me entirely from the view of the user of engineering graduates and not from that of the teaching profession. It has been my good fortune to have the training of several hundred engineering graduates and, therefore, it must be apparent that, in the criticism which I have to offer regarding these young men, I am not opposed to engineering education as a preparation for life. On the contrary, in all cases where possible, I invariably select an engineering graduate for almost any large position which needs to be filled. I want to make this matter perfectly clear because in the kind of criticism that I propose to present, one is very apt to be led to the conclusion that I am opposed to the engineer as he is now trained.

There ought to be no question in the mind of any impartial investigator as to the enormous value of a college engineering education for success in actual, practical life, in commercial life, in manufacturing life and in engineering life. On the other hand, I think probably you gentlemen are not in very close touch with the general public opinion of the country as regards young engineers.

You are, many of you, inundated with letters asking for the services of your young graduates, and from these it is perfectly natural to suppose that the country at large wants

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them very badly. Now I do not think there is a shadow of doubt but that the overwhelming majority of employers of this country want to have nothing to do with young engineers who have just graduated from college if they can help themselves. That is a fact, and I think that it is one you gentlemen ought to appreciate as having a great bearing on the educational problem. Mr. Crane, of Chicago, has very aptly presented this type of men. He stands, however, almost alone in publicly presenting this view, and I have heard Mr. Crane laughed at, sneered at and held up to ridicule to such an extent that it appeared to me that Mr. Crane's opinions on the subject are hardly even tolerated by the men who are engaged in university teaching, whereas he is voicing the view of the great majority of the employers of this country. They say nothing, but they agree over and over again with Mr. Crane. I want to give one illustration of this. I was recently in the Middle West at one of the largest and most successful manufacturing companies in the country. They had present some thirty of the heads of their departments; their president, vice-presidents, general manager and superintendents, and after I had said a few words in regard to the fact that there were so few college employes in their organization, the president of the company who was a college man himself, rose and said: "Well, this is an entirely new experience to us. Here is a man for whom we have a certain regard, and who has the reputation of being a practical man, who tells us we had better use the college man instead of the commercially trained man." They almost all laughed, although there were four college men among them, yet those four were as firmly convinced of the inutility of the recently graduated college man as any of the rest of them.

I want you to appreciate that that sentiment exists right now very largely in this country. Any college professor can satisfy himself as to whether the average employer wants college graduates by going in any one of our large cities from one manufacturing or engineering establishment to another just as he finds them and soliciting employment for young

graduates. I think those who have had the longest and largest experience with them want them the most, but I venture to say, they only want them on the average after they have been out of college for one or two years. They want someone else to take them first.

There is one exception to this not wanting to employ college men which is quite prominent. The large electric companies are employing them on an extensive scale, but it is my opinion that they are, to a large extent, exploiting the young men; that the opportunities which they get in the large electric companies are in no way comparable to the opportunities which would be open to the same young men if they went into smaller industries with their greater diversity.

Now that is one side of the question. The other side has come to me from my personal observation. I think it is also true that nine out of ten of these young men are dissatisfied for at least one or two years after graduating. They find their employers unappreciative and exacting. They are not given any kind of opportunities commensurate with their education and what they are able to do. They are asked to do work that mere boys could do. Almost invariably, they want to leave their first employer, and it is only after going to their second or third that they become aware of the fact that the boys that they make light of are the ones who can do things and are the ones favored by the employers, and that all of the employers of the country are not really unappreciative. Some ten years ago I made up my mind never to employ a college man who had not been out two years at least, if I could help myself. The young graduate will by that time have learned something about life and what the world is.

Now are those two conditions unavoidable? Is it necessary that the young graduate should be turned out so that he is himself unhappy, discontented for a period of two years more or less after he graduates? And is it necessary that the young graduate should go out with such an education that the average employer, who is an honest man, who

really believes that he is right, feels that these young men are not what he wants? Is that condition indispensable? I most firmly believe not. I believe that the young graduate can be turned out so as to be useful right from the start, and I believe that there are two facts in particular which are responsible for this condition of affairs, both of them remediable.

The first of these facts is that during four years that these young men are at college, they are under less discipline, and are allowed a greater freedom than they have ever been allowed before, or will ever have again.

I will cite some illustrations. In most universities and colleges the student is given, every term, a certain number of cuts for which he is held to no responsibility. He can simply absent himself from recitations, from lectures, from duty that belongs in the college course, and no one ever asks what he has done, or where he has gone. If that same young man absents himself once without a reasonable excuse, when he gets into business, he is usually hauled up and asked in the most impertinent manner, why he was away. No cuts in business, no talk about how many cuts a man has. The second or third time that he stays away without reasonable excuse, he is discharged. Young college men work when they please, and as much as they please, the only restrictions being that they have to pass certain examinations. Their habits are left almost entirely to themselves. When they begin commercial life those habits are regulated and rigidly prescribed by some one else.

Again, the young college man gets it firmly into his head, that a good reasonable excuse, I do not refer to an unreasonable one, is about as satisfactory as a result. Now the employers want results, and whether the excuse is reasonable or unreasonable, makes little difference. They want results, not excuses.

The radical difference in the treatment which these young men receive in college, from what they receive afterwards, is, to my mind, the lesser of the two reasons for the fundamental facts that I have described, namely the unhappiness of the

young man when he gets out, his failure to fit into his surroundings, and the great lack of demand for these young men throughout the country.

The more important reason for these unfortunate conditions is this; that for twenty-two years these young men are allowed to go without even a single look at conditions which they are to face throughout the rest of their lives. The work of the student, of the boy and the young man, is that of absorbing; he is engaged in getting things stored in his mind for himself, for his own use. That is his life for twenty-two years. The moment he gets out of college he begins directly the opposite. Absorbing ceases and becomes a very minor part of a man's work. He begins giving out the few ideas, or the many which he may have gotten, to help some one else. He has been served for twenty-two years by some one else, the moment he gets out he begins serving others. Is it any wonder that these young men find great difficulty in suddenly changing from the attitude of sponges, or absorbers to that of men actively engaged in doing things for the benefit of some one else? I think the wonder is that they adjust themselves so quickly to this reversal of their life's work.

The central idea that the boy gets at college is training, training of the mind, storing the mind full of things. Now I say, without the slightest hesitation, that for success in life, intellectual training comes second or third. Without the slightest question, character comes first; common sense, second, and intellectual training third. The entire emphasis of the college life is on intellectual training. As long as a man commits no offense which sends him to jail, it is a very small part of the business of those engaged in the management of our universities as to what these boys do.

What is the remedy for these two faults? I do not believe there is any panacea for all faults, but I do believe that there is a great palliative possible. I believe that every young student in our colleges, from the student who intends to be a minister, on the one hand, to the mechanical engineer, on the other hand; I believe that every student should leave college

at the end of his freshman year and spend at least one year in actual hard work in a shop of some kind. I say a shop, because he will be certain of being under careful and constant supervision when working in a shop as a workman, alongside workmen.

I would not give them this year of shop work with the idea of getting intellectual training. If they do it it is a mere incident. I would send them there mainly for the purpose of giving them a real look at life's work and giving it to them early enough to affect the last three or four years of their college life.

When they start at work in a shop, under good rigid discipline, they then begin to get the kind of character training, which is almost entirely lacking at college. They then begin to learn the great lesson of life, that almost nine tenths of the work that every man has to do is monotonous, tiresome and uninteresting. They then start to develop the character which enables them to do unpleasant, disagreeable things. This is the greatest training, to my mind, which they get in the shop. They learn that life is made up mainly of serving other people, not that the world is there to teach them something new. I think that almost invariably young graduates start into the shop with the common idea, "Now I am here to learn something, to get something in this shop that is going to be a fine engineering education for me." In this they fail at once, for there is no great intellectual training in the shop. Many of them cannot stand the monotony, and since they do not realize the importance of this ability they fail to get the real character training that comes from monotonous, hard work.

There is another thing that they learn, which is of enormous importance for these young men, and I think it has more to do with making them earnest and determined than anything else. You could lecture to them and talk to them from now to doomsday, and tell them that the man who goes along the street in greasy overalls, that the man who runs a lathe, is mentally born their equal and they won't believe it. They may acquiesce, but way back in their heads they say, "Oh,

yes, I will believe it, but it is not so." That is their mental attitude.

Young men who work in any first-class establishment will find that many of the workmen who cannot talk grammatically, that men who chew tobacco, slouch along the street with greasy overalls on, who hardly look up, who are scarcely willing to speak to you politely as you pass them, are intellectually as clear as they are. That is what the young men learn through one year's work in a shop. I remember very distinctly the perfectly astonishing awakening at the end of six months of my apprenticeship, when I discovered that the three other men who were with me in the pattern shop were all smarter than I was. Now when a young man gets it clearly in his head that he is made of the same kind of clay, physically as well as mentally, as these other men, then his only hope not to be outstripped in the race lies in getting a better education. For he sees clearly enough, if he uses his eyes, that it is energy, grit, pluck, determination, ability to stick to it, character which makes for success in the manufacturing and engineering world. He sees that many of the workmen have quite as much character as he and that his only hope of outstripping them lies in knowing more than they do, and he goes back to college with the firm determination to get a better education. This development of character and earnestness of purpose I look upon as the greatest good that comes from work in the shop.

Professor Furman, of Stevens Institute, published last winter, in the *Stevens Indicator*, a record of the careers of the graduates of Stevens Institute. In the group of successful graduates of Stevens Institute more than half were engaged, not in engineering, but in executive work, in managing, as presidents, vice-presidents, superintendents, managers, in some capacity in which engineering was secondary and incidental, and in which the real work was executive work. Now these statistics are of the greatest importance to young engineers since they show what has taken place with the graduates of one of the oldest mechanical engineering schools in this country, and by inference, therefore, what is likely to happen to them.

At college a very large amount of time is given up to the study of materials. Practically the whole chemical course is the study of materials. A very considerable part of the course in physics has to do with materials. The greater part of the work in a mechanical laboratory is a study of materials. Do you, gentlemen, realize that the great raw material with which more than one half of the successful graduates of our technical schools have to deal, receives not a single hour of study at our colleges and universities, not one hour? That the great raw material with which the managers, superintendents, presidents of every one of our large companies is dealing is workmen? And that one half of the students who are finally called upon to manage workmen, learn nothing whatever about them at college. At twenty-two years of age on the average they land outside of college without the slightest knowledge of the great raw material with which more than one half of them will have to work throughout their lives.

Now, those of you who have worked much with workmen, will realize fully that it is next to impossible to study them from the top. Workmen can only be properly studied side by side and shoulder to shoulder. The man who undertakes to study them from the top gets a superficial knowledge of his men, and in many cases an entirely wrong and misleading idea. The only way that a man can become familiar with the line of thought of his workmen, with the methods of reasoning by which they approach the great problems that are in their minds, is by becoming intimate with them, so that they forget that you are not one of their kind, and genuinely tell you what they think.

I say without the slightest hesitation that no man is well equipped to manage workmen who cannot say ten sentences consecutively to a workman and have that workman know at once that he has worked as a workman. Absolutely, in ten ordinary sentences, if it be about work, the workman will form a pretty correct idea as to whether he has been a workman or not. And until a man is intimately acquainted with them and knows their methods of thought, their methods of expression

and the way they look at things, he is at a very great disadvantage as a manager.

Just now, in this country, we are facing a great problem in the management of our men; the problem upon which, I think, it may be said with almost certainty, that England has made a grand failure. We are facing that problem, and are up against it hard. The problem of soldiering, that is, of deliberately and intentionally working slow instead of fast, and purposely turning out a small instead of a large output. No man can properly and thoroughly appreciate this great problem unless he has worked among them and seen them soldiering, knows their arguments for and against it and has some idea of how to remedy this great evil; the defect which has come close to ruining many English industries, and is on the road to do the same thing for us.

Now there is one more thing. More and more is management becoming a question of coöperation on a large scale. The whole training of the young man while he is in college is an individual training. He has not the slightest training in coöperation, except possibly what he gets from his baseball or football team in the university; and yet every year the problem of successful coöperation becomes a greater one.

These young men at twenty-two go out without having seen any coöperation, thoroughly unfitted for it in many respects; thoroughly unfitted to do what they are told to do promptly and without asking questions and making suggestions. They will not become one of a train of gear wheels, and it is absolutely necessary for every man in an organization to become one of a train of gear wheels. The training that the young man receives at college in no way fits him for modern coöperation. But a year in a shop will give him at least a good look at it. He has to work as one of a train of gears during that year.

I do not think there is any equivalent for this work. Certainly the university shop is in no wise an equivalent. There they are in competition, not with men who are engaged in working for a living, but with other students. They are not rubbing against other men and getting their viewpoints, and at the same time learning something as to how work ought to be done.

They undoubtedly get a little good from their university shop work, but as far as the great experience they ought to have, the character training, and the study of men, they get nothing. The thing that comes closest to it in college is three or four months of vacation work in an outside shop. Even during this time, however, they fail to get the greatest good out of it because they go into the shop mainly with the idea of learning something. For the three summer months shop work is a novelty to them and they fail to get right down to the real monotonous grind which trains character. Then again, in three months, they cannot get close enough to the workmen to know their viewpoints.

Most of you professors are telling your students that they had better work as a workman for a year or so at least when they go out. About one in fifty does it. They start with the idea of serving an apprenticeship, but they do not stick to it. Even when they go in with the best of intentions they cannot get away from this habit of absorbing, they cannot get down to monotonous, tiresome work. They find that they are not really learning very much. They feel that they have a fine college education which is being wasted. They find themselves doing work which can be as well done by a boy of fifteen or sixteen and which does not require any particular scientific training.

Thus at twenty-two to twenty-four years of age with a fine theoretical education they are virtually in competition with boys instead of men, and in this competition their education is of but little help.

They find themselves ordered about and corrected by men whom they look upon as their intellectual inferiors.

Their four years of college life have made them intellectually as well as physically fastidious. What wonder then that this work is exceedingly irksome to them. What wonder that they fail to give satisfaction in work of this sort to those who are over them, and that most of them do not stay at this kind of work long enough to become familiar with practical working conditions: and that too large a proportion of them

find their way into the drafting room, which to engineering bears more or less the same relation that book-keeping does to business, where they have, however, more agreeable surroundings, shorter hours and where their education immediately counts for something. They realize years later that they have missed the great opportunity of their lives to learn the many simple practical things that are fully as important for ultimate large success as their theoretical knowledge.

Quite a large proportion also of the young engineering graduates feel that they can hardly afford to spend one or two years after graduating at a work which pays them such small wages that they are unable to live on their earnings even in the most modest way. And practically all of them, even if their parents are willing to continue supporting them, are anxious to become self-supporting.

The effect of all these combined conditions is that but a small proportion of young engineers actually ever get the invaluable experience which can only be had from working as workmen. This is a fact, not a theory. If however, these young men were forced to leave college for a year's apprenticeship at the end of their freshman year, it would come as a natural part of their training from which there is no escape. And being younger, less fastidious and more adaptable they would come into closer and more intimate contact with the workmen around them and get at least a fair knowledge of working conditions. I feel sure that this training would make them almost immediately useful to their employers after leaving college, and therefore greatly increase the demand for college graduates.

My own experience with using young men coming directly from college was so unsatisfactory that about ten or twelve years ago I made up my mind not to take another young college graduate until after he had had two years' work outside of college but, in going through the list of those who had worked under us, I found that there was a certain set of young college men who were satisfactory right from the start. Namely, men who had by necessity been forced to

leave school and go to work. So I found that I had to modify my conclusion, by saying that I would not take a college man unless he had been out of college for at least two years, or unless he had worked as a workman before he graduated.

Now I want to strengthen this conclusion by some facts. The investigation by Professor Furman, above referred to, of the graduates of Stevens Institute, has led him to formulate at the end of his paper two sentences of the greatest importance to all teachers and to all engineering students, as follows: "An apprenticeship of one or two years has stamped itself as the surest road to obtaining success in after life." That is his most important conclusion from a study of the graduates of Stevens Institute. A second quotation is: "A large percentage of the older graduates that now stand highest in their professional work are those who have started in as machine shop apprentices." This is not someone's theory but is a fact of the greatest importance developed from a study of carefully gathered statistics, and I do not suppose that Professor Furman had any more notion that this fact would be brought to light when he started that investigation than I or anyone else had.

One thing more, the joint committee appointed by seven of English engineering societies, with, I think, three professors from the universities, unanimously voted that it was desirable for students to have a two years' apprenticeship before graduating as engineers. I think this is a very remarkable recommendation. It goes very far toward bolstering up the conclusions which I have arrived at, that the accredited representatives of seven great engineering societies of England should recommend unanimously two years of apprenticeship for students before being allowed to graduate either as mechanical engineers or as any other kind of engineers.

As to post-graduate engineering courses which are being so strongly advocated by many professors. In so far as such courses in our engineering colleges interfere with the

good that comes from getting in touch with actual work while young, just to that extent those post-graduate courses are bad and much to be deplored. I do not think that the average young man needs any post-graduate course. He needs other things. He needs closer touch with actual life, and this tendency in our universities to lengthen their courses out to five or six years is a most unfortunate change. Certainly for the average young engineer it is a step in entirely the wrong direction.

Now, as to the liberal education which it is claimed that engineers need so badly, I believe that one year spent in close contact with a totally different class of men from those with which they have been brought up—working under practical conditions, with men struggling for a living, is vastly more broadening, for instance, than a year of travel abroad. Personally I had both of these experiences. I am very sure that the thing that did the most for me was the apprenticeship and not the years of travel. If I wanted to give a boy a broad liberal view of life, I would get him early in contact with men who are really working for a living and make him see how the other half lives. That will give him a lasting sympathy for all classes of men.

One thing more, is it possible or practicable for young men who leave college at the end of their freshman year to get the opportunity to work for a year in a shop and then return to college? I feel absolutely sure it is, provided these young men are sent out to work under working conditions and expect no special favors. If they are sent out to get an education, no. But if they go into the shop for the purpose of learning how to do a day's work, they are the finest kind of raw material. Take the average young college man. He has some bad ideas, but all you have to do is to mould him to your needs, give him common sense and he becomes a great addition to the working force, and when the shops begin to take these young men from our universities and colleges, particularly if it becomes a regular thing, that every year from such and such a college we can get eight or ten men,

I predict the supply will not equal the demand. I had some difficulty two years ago in getting one of our manufacturers to take a single college man, although he was himself one of the most distinguished graduates of a technical school. After trying one or two of them for a year, he now wants all he can get of them.

DISCUSSION.

PROFESSOR HIBBARD: While listening to Mr. Taylor's address, I was reminded of a little story of a camping party of fellows, and they agreed that any man who found fault should be obliged to clean the fish and wash the dishes. Well, there was one jovial fellow that they never could catch finding fault, and so one morning they made it up on him to put some very bitter stuff in his coffee. He started to drink it and put it down, and as he tasted it, he said: "My but this is bitter—but I like it." We have received a very scathing criticism from Mr. Taylor, and everyone of us appreciates it.

Speaking as an engineering professor, I shall add a few suggestions as to the practical ways by which we approached or may approach the ideals of Mr. Taylor. I believe that we have not appreciated the privileges that we have in accepting and formulating the guidance of our engineering alumni. In conversation with an engineer at the recent railroad convention of mechanical engineers at Atlantic City, he said to me that the engineering school of which he is a graduate had just had a new dean appointed. He said, "It is so unfortunate that the new dean is a pure theorist; he is not an engineer, he is a scientist." I asked him what he had done as an alumnus of that institution to see that the right kind of a dean was appointed? He finally replied that he had not done anything.

If the right kind of deans and professors are to be appointed if the right kind of instruction is to be given, it must be with the help of the engineering alumni. They are closer in touch with practice than the professors can possibly be. We may spend our summer vacations in engineering work and

in getting into the atmosphere of the practicing engineer, but the rest of the year we are, and must be, occupied in teaching.

You will be interested to know what is being done by a certain group of alumni of one of our engineering institutions. It was my privilege, during my ten years at Cornell, to aid in the introduction of a number of Cornell graduates into the railroad world and the railway supply business. Some three or four years ago these graduates started the custom of having an annual banquet of mechanical officials and supply men. As a Cornell alumnus, I attended one of these banquets last Saturday. Among the speeches at that banquet were several on matters relating to the teaching of engineering. It was shown how engineering training is useful to the mechanical official, to the supply man, and to others in the railway business. This sort of program got men away from the old-fashioned sort of alumni gatherings which began with toasts, songs and college jokes. At this banquet there were also reminiscences of the days when we were being taught at our alma mater, and of all the chums whom we remembered so delightfully. Next year there is to be a further improvement in the arrangements for the banquet. In the past there has not been a sufficient interest in the discussion on the part of all the men present. Next year the men who are likely to be invited to speak are to inform all the other men of the topics that are to be discussed. This will create a greater interest in the discussion of the topics presented. The ideas gained from the discussion of these topics will be useful in guiding the Cornell and other professors who are present. We believe that for other engineering alumni and other engineering institutions such a procedure would be helpful.

Not only should the alumni help in the selection of engineering professors, but they are also needed to restrain and guide even the presidents. Recently an eastern college president refused to allow the announcement of the recommendation of a year's shop apprenticeship as preparation for an engineering course. He was afraid that if the students got a year of shop work after high school, they would not come

for a course in engineering. There is a pressing duty before us in this line, not only for engineering alumni but for the engineering societies of this country. I have been interested this spring in the establishment of the St. Louis branch of the American Society of Mechanical Engineers. Before the branch was formed it was decided that there should be a definite object in view, on the ground that a new organization must justify its organization. It seemed that here was a great opportunity for paramount influence in saying what shall be done in our engineering schools. The branch has been formed, and if the engineering educators who are a part of it are not mistaken, engineering institutions in the Mississippi basin will receive great assistance from aid, guidance, influence and interest of the members.

I know of no engineer who is president of a general university. I hope that this will not always be the case. Meantime, let us hope that the engineering profession will make it impossible for a university president to cut off such a recommendation as I have mentioned, or to appoint as dean of the engineering school a man who is not an engineer.

It will be interesting to Mr. Taylor to learn that some of his suggestions are already in force in some of our institutions. For instance, among my students this spring was one who had resisted my efforts to bring him up to the point of achievement in a drafting-room course. At the end of the course I was obliged to tell him that I intended to give him a "failure," requiring him to repeat the course. I said: "I am going to give you a failure because you have not achieved results. I have had draftsmen work for me whom I paid eighty or one hundred dollars a month, and if they had done as you have done, I would have discharged them long ago. I cannot dismiss you from the university for a failure in this course, but I certainly can make you take it over and achieve results. You may have had some very excellent theories, but the results are what we want, and the results are what we propose to get." This treatment was good for that boy. He took it manfully and will, I think, amount to more than he

would otherwise. Mr. Taylor said that nothing is being done in the way of education to prepare the graduate to handle men. In one institution at least there has just been introduced a required course of one year, on the subject of the handling of men. The teacher who gives the subject has made a long study of it. He started with his own practical experience and has profited greatly by Mr. Taylor's previous observations on the same subject. The subject has been reduced to a science, so that it can be taught in engineering schools. These young fellows will not go out entirely ignorant of how they may best cope with the problem, and of how they may profit by their experience after graduation. Undoubtedly a lecture course on the handling of men is not going to qualify graduates to handle men. What they need is experience. It is, however, going to put them in possession of the fundamental principles of the science of management, so that they may earlier become managers of men.

DEAN GOSS: I am very glad to have had Mr. Going and Mr. Taylor unburden their minds for our benefit. We have come to this meeting, some of us, from long distances, that we may learn each other's point of view, and I am sure that no teacher of engineering will go away after listening to these addresses without feeling a desire for better things. Mr. Taylor has criticized us severely, but I believe that in the main the things that he would like to accomplish are the things that we as teachers would like to see done. But, however this may be, it should be noted that, notwithstanding obvious deficiencies, the colleges of engineering in this country stand justified by their results. However fair may be the criticism that has been urged, this justification as seen in the successful lives of their graduates should not be forgotten. Moreover, it is well to remember that the colleges of engineering in this country are in their very infancy and they require time in which to outgrow their swaddling clothes. Give us time and many of the defects to which our attention has been called will disappear.

DEAN GOETZE: It has been my good fortune to have the opportunity to discuss with Mr. Going the ideas and sugges-

tions which he has laid before us to-day. I endorse all that he has suggested and the conclusions at which he has arrived. In fact, we have been trying at Columbia during the past few years to carry out a number of these suggestions. One of his conclusions is that there should be a closer union between practicing engineers and professors; that they should work in hearty accord. With that end in view we have had, during the past year, no less than forty-seven practicing engineers lecture to our students. Among them was Mr. Taylor himself, who gave the young men one of his characteristic, straight-from-the-shoulder talks. It was with a great deal of pride that I saw them take their medicine and applaud him most enthusiastically.

Another of Mr. Going's conclusions is that the engineering faculty should do outside work in order to keep out of the rut and abreast of their profession. At Columbia we do not want in our engineering faculty any man who is in a rut; who is not abreast of the profession. We want no one who is not in touch with outside work; in touch with the men in his profession who are outside of the university. We think that within reasonable limits the teacher can bring to his students in that way far more than he takes away.

A third conclusion of Mr. Going is that there should be a closer relation among the alumni. That we are also trying to promote and are meeting with very encouraging coöperation from them. Mr. Going was in error when he stated that he is a minor member of our faculty. On the contrary, he has been a very important one. He has organized our course on works management, and has carried it on successfully with the aid of five or six of the foremost experts in that line in this country.

PROFESSOR DIEMER: I wish also to emphasize the point which has been made, namely, that it is very desirable not only to believe and acquiesce in the statements of Messrs. Taylor and Going, but to show our belief by acting accordingly.

I am familiar with the project which Mr. Taylor advocates, of having young men spend one year in the shop. He has

made arrangements by which certain men will be taken in the most excellent shops, and yet I have had difficulty in getting the right kind of men to avail themselves of the opportunity. I think the same would be true if an attempt were made to have the governing authorities of colleges advise the members of their engineering faculty to spend a year, at least, in actual work. There is an opportunity here for organized effort and coöperation similar to the work of the joint committee recently appointed by the larger national engineering societies, the object of which is to make the engineer realize and reach the place which he should occupy in exerting an influence in public affairs. This coöperation can be brought about by members of our society appearing before manufacturing associations, just as Mr. Taylor and Mr. Going have appeared before this association, and making plain our desire to work in harmony with the manufacturers. To reach the parents so that they may see the course of procedure which is advisable for the students, will be another and more difficult problem. Perhaps they may be reached through the alumni. It is very desirable indeed to have this coöperation of teachers, manufacturers, parents and alumni.

The institution which I represent has, like other colleges, availed itself of Mr. Taylor's kindness, as well as that of other practical men, to give us practical talks. We have also been favored by several large corporations, notably the Pennsylvania Railroad. The last-named company has sent us their men in charge of their dynamometer car, and the men with their air-brake construction car. This is a line of coöperation that could be followed out with other manufacturing industries. Thus for a limited time, without interfering with the actual work of a manufacturing establishment, the teaching force and students could have the advantage of seeing the best methods in actual work.

MR. SAWYER: It occurs to me to ask, first of all, what is the trouble with our boys? Why should we ask them to be older than they really are? This spring I had occasion to have some screens put up. I asked a couple of young fellows to come

over and put them up. I showed them that the screens were all numbered and that they were made to fit together. The young men were juniors and had had all the shop work that we give. I felt that they had been trained enough so that they ought to be able to put up a set of screens. I watched those two young fellows take the screens out on the lawn and start to clean them off. The way they handled those screens—well I stayed and oversaw their work. I finally finished the job myself. Now what was the trouble?

These were good boys, but they were thoughtless. A neighbor said: "These boys are just like my own boy, who is in the same class. They come here and live in the dormitories with no responsibilities." I wondered what I would do with my boy, if I had one, to get that out of him. Then there occurred to me a remark which had been made to me by a man of experience. Speaking of his own son he said, "I would not have him different. I do not want to put an old head on his shoulders; I do not want to make an old man out of him before he gets out of school."

I agree entirely with Mr. Taylor and should like to adopt that plan, but what would be the result of taking the boy out of college at the end of the first year and putting him at work a year? It would have the same effect on him then as it does after he has left college and has actually gone to work. Under discipline, with a foreman over him, compelled to comply with the shop rules and hours, he will be made an old man before his time. By the time he gets ready to graduate he will have as many wrinkles as we have. We are here to devise methods of training young men so that they may go out of college with increased efficiency. If motors of 90 per cent efficiency are made, we say, "Let us build one of 95 per cent.," and so on. Are we going to do the same thing with the young college man? If we can turn him out now with a certain efficiency, let us endeavor to turn him out with an increased efficiency. I am inclined to think, however, that he would be prematurely old when he graduated. Is that desirable?

PRESIDENT HOWE: I agree with very much that Mr. Taylor

has said. When I was coming to this meeting I met the head of one of the largest manufacturing establishments in Cleveland. He told me substantially the same things that Mr. Taylor has said this morning. This gentleman is himself a technical graduate. He said that, while he prefers to have technical graduates around him, during the past ten years only three of them have made good. It is quite difficult to reply, upon brief notice, to those arguments of Mr. Taylor with which I do not agree. I totally disagree with him on some things which he has mentioned—perhaps because my experience has been in the teaching profession. I am sure that if he had been a teacher for twenty years, he would not believe as he does now. Each man looks at these problems from his own standpoint; Mr. Taylor looks at them from his side, while we look at them from the standpoint of the teacher. But notwithstanding we ought to get a great deal of good from this exchange of opinions; we ought to get very much closer together, especially as Mr. Taylor is in sympathy with what we are doing.

Mr. Taylor referred to Mr. Crane. The first article of Mr. Crane's I ever read was one published in the *Railway Journal* a few years ago—an address delivered before a railway club. Mr. Crane said in that address that an experience of many years had shown him that a training in a technical school was absolutely worthless to the boy who was going to be a mechanic. Does any one suppose that a boy trained in a technical school will ever be a mechanic in a shop? This address, as well as a number of others, shows that when Mr. Crane talks about technical schools he is talking about something of which he is entirely ignorant; that he has no conception of what the modern technical school is doing.

Mr. Taylor says that there is little discipline in our colleges, that results are not obtained, and that students work when they please. He states that in these respects the boy is under different conditions in college from what he is in practical life. This latter is true to some extent—the boy is necessarily under less discipline. Mr. Taylor most certainly would

not propose to put the boy, in college, under the same discipline that he will be under when he leaves college.

Yet, the boy is under a great deal of discipline in the technical school. In my own institution, the students come to work at eight o'clock in the morning and stay until four o'clock in the afternoon. There are not more than two or three hours in the week when they are not in class room or laboratory directly under control. The discipline of the class room and the laboratory, it seems to me, is an efficient discipline. It is different from the shop because it has to be. The results expected are different, but in both places we do demand results. It is probably true that we are not as stringent in our demands for results as we ought to be, but it is not true that we do not get any results.

For twenty years in my mathematical teaching wherever problems were concerned I have had but two grades—zero and one hundred. I have demanded results in mathematics and a solution of a problem has been either right or wrong. I would not say that every one who has charge of a laboratory should demand that when a student goes through an experiment he should secure an absolutely correct result, but I do hold that the instructor should demand as accurate a solution of the problem as can be obtained with the time allowed and under the given circumstances. A student who performs an experiment but once cannot be expected to secure as accurate results as the man who has performed that experiment a thousand times; but the student can be required to understand the problem thoroughly both in a theoretical and a practical way, to comprehend the manipulation of the apparatus, the method of computing the result, and to obtain a reasonably close answer. If there is time a student can be required to repeat the experiment several times, improving with each repetition. I believe that in our technical schools students are required to work in this way and that accuracy is one of the requirements.

To a certain extent a student works when he pleases and is not obliged to work from seven in the morning to five in the

afternoon; we cannot force him to do that. Mr. Taylor should remember that these students have certain hours of lecture work and certain hours of laboratory work. These take up nearly all of the day—almost as many hours as the man in the shop puts in. After that, the student must prepare three or four subjects for the next day's recitations. He works many hours more than the man in the shop and should therefore be given a certain amount of freedom outside of his hours in the lecture room and laboratory or he will break down as students have done in thousands of instances. As the conditions are so different we cannot give the same kind of training as in the shop, but there is no doubt that in our technical institutions we are holding the boys under a fair amount of discipline. We see that their work is systematically and regularly done, we hold them to a certain schedule every day and every week, and we require them to pass certain tests and examinations.

I agree, also, with Mr. Taylor that character and common sense are essential qualities in the man who is to go out into the world and make a success. One remark made by Mr. Taylor, however, was a little too strong—that in regard to the character training which is given at college. In a technical school at least the boy's character is trained. I believe the course of study, the exercises in class room, lecture room and laboratory, the student life, the responsibility that is reposed in him by parents and faculty, the participation in student activities, etc., all tend to the formation of character. Men leave the technical school much stronger mentally and morally than when they entered, and the great majority can be depended upon to look at things in the right way and to do the right thing. They do this in college, and they are going to do it afterwards. There is always a response in the right direction when we appeal to a student's common sense or to his sense of justice. I believe the average student has high ideals in regard to work and character and I think he is constantly striving to reach those ideals.

I believe, also, in the shop work which Mr. Taylor has spoken

of, although I do not agree with him as to the best method of teaching it. Every student who is going into mechanical or electrical engineering should have a large amount of shop work and every technical school requires that a student shall do a certain amount either before he enters or during his course. But I cannot believe that the man who is going to be a civil or a chemical engineer should be required to do much work in the shop. It is a great advantage to a fellow to have had some shop work before entering college or to gain some experience in this line during summer vacations, but from a pedagogical standpoint it would be very bad practice to take a man out of college after the freshman year, put him in a shop where he would have no intellectual training, and then afterwards expect him to resume his studies. In the first place, he would probably not go back to college, because having become unused to study it would be exceedingly difficult for him to resume it again. It seems, therefore, that Mr. Taylor's plan is entirely impractical for the great majority of students. If a technical student wishes to become the superintendent of a shop or to be identified with shop work, he should go into the shop after graduation and thus secure all the advantages which Mr. Taylor has named, unless he has had the advantages of shop practice before entering the technical school.

In regard to the study of workmen, I fully agree with Mr. Taylor that we do not give any instruction in regard to the methods of dealing with them. The reason for this is that we know very little about teaching this subject, because success in dealing with men depends very largely upon the individual. Theories may have something to do with it, and perhaps certain lectures could be given which would be of great advantage, but they would not be very helpful to the man who had not the faculty of handling men—although they might be of some advantage to one who had that faculty. If Mr. Taylor can write any articles or books which will help us along this line, he will be conferring a great benefit upon both the faculties and the students of our technical schools.

PROFESSOR NORRIS: I am very much interested in the apprenticeship course, because I feel that it is a proper thing for the student to have, at some time before, during or after his college course. It seems to me that Mr. Taylor's view is the right one, namely, that the apprenticeship is not a post-graduate course of instruction, but an opportunity for a young man to learn what a day's work is, and what workmen are. My own shop work was obtained between high school and college. I know now that I did not feel any great desire to learn in the shop. I did not intentionally use it as an educational institution, but felt about as the other young fellows in the shop. I believe, however, that I learned what a day's work was. I am inclined to agree with Mr. Taylor, that the earlier this apprentice work comes, the earlier the young man is apt to get ahead.

PROFESSOR SWAIN: I agree in the main with what Mr. Taylor says. In regard to the appreciation of engineering graduates, I doubt the truth of his statement. It certainly does not hold good regarding employers of graduates in civil engineering. If it is true regarding manufacturers, I think that it is also true that there is a much greater appreciation of technically trained men now than forty years ago. When the technical schools were started, there was not the necessity for a technically trained man that there now is.

DEAN GOETZE: The existence of technical schools is fully justified by what they are doing and the appreciation of the men they turn out is increasing every year. The problem of education is a very complex one, involving many elements. One mistake made by many of us is in forgetting the character of the student while he is in school. We treat him as if he were a fully developed man. The raw material the teacher has to do with is student, and only certain things can be done with that material. I agree with Mr. Taylor in regard to the lack of discipline. This lack is greater in colleges than in technical schools. The colleges and technical schools should do all they can to train the character and not simply the intellect.

A year in the shop is a good thing for the student to have. And yet I do not think that it is the only panacea for the ills complained of. With a thorough appreciation of the importance of discipline, and with a training of character in addition to the training of intellect, the students of our schools can be turned out to take part immediately in the work of our country with efficiency. They should not need one or two years of training by somebody else before a man like Mr. Taylor is ready to take them. I disagree entirely with what Mr. Taylor has said in regard to the post-graduate work. There are other things in which the young man should be trained besides the appreciation of shop workmen. With summer work throughout a course of four years, a young man may get practically a year of outside work. When he graduates, he is not a broadened engineer, but simply a bachelor of science, and will have to begin at the bottom. If he goes out of college with a due sense of humility and not with a sense that he knows it all, I believe that Mr. Taylor would be willing to take him.

UNIVERSITY EXTENSION—"AN INSTRUMENT OF THE STATE IN ITS UPBUILDING."

BY LOUIS E. REBER,

Director, University Extension, the University of Wisconsin.

In Wisconsin it is believed that the university, controlled and supported by the state, should be of service to all the people of the state in all their needs. As part of the system of public education, who shall say that it should limit its field to resident students and to higher education? If it is better able than any other agency in the state to take unto itself certain new functions and meet unquestioned demands, why should old, conservative, academic views stand in the way? The results achieved in Wisconsin during the past year by the University Extension Division should tend to dispel the conservatism of the cloistered scholar, who regards education as synonymous with advanced intellectual achievement, a thing for the elect only, which must be carefully protected to avoid the possibility of its becoming common. I am glad to say there is but little of this conservatism in the University of Wisconsin, and daily it is lessening.

With this attitude assured, the question arises—How may the University broaden its service to the educational interests of the state without interfering in any way with agencies already at work? Certainly accurate knowledge of conditions existing in all parts of the state, is an essential first step toward the solution of this problem. The state, therefore, must be divided into districts and a university representative placed in each district with such assistants as he may require. The function of this representative is to study the social, economic and industrial conditions of his district and in coöperation with school boards, library boards, town councils, civic leagues and all such established organizations, to determine how the university can best serve the people. In Wisconsin

the district organizer arranges a central office in which the work of the district is developed, for lecture, reading, and correspondence study courses, exhibits, demonstrations and conventions or institutes relating to the industries in his district. One district, that including the city of Milwaukee, has enjoyed the advantages offered by university extension for some time, with results beyond the most sanguine expectations. With similar organizations covering the state, one may confidently believe that no bound can be set to the possible usefulness of extension.*

As has been implied, it is not the object of the Extension Division to usurp the prerogative of established bodies but rather to assist them and, if possible, add to what they are doing by means strictly compatible with their interests and plans. The university stands ready to turn over any of its activities in a community to the community itself when it is capable and desirous of undertaking them. Local trade schools, night schools and continuation schools generally, are to be encouraged and at all times would-be students are advised to pursue the course that ultimately will bring them the greatest return in the broadest sense. Such a policy calls for broad-minded, sympathetic district representatives—men who understand human nature and are capable of estimating a young person's possibilities.

The service from the university to a given community may relate to municipal problems, hence the necessity for a municipal reference department, to serve city and borough councils somewhat as the legislative reference departments aid the legislatures in different states. Town or city may need an awakening in some phase of civic betterment—an institute or series of lectures will prove helpful. The Extension Division is prepared to supply speakers who will lecture upon topics of general interest or adapted to meet local conditions. One might enumerate indefinitely problems which may arise which, through the instrumentality of its extension field organization, the university may help to solve. How may women's clubs,

* Since this paper was prepared a second district has been organized and its work is successfully established.

farmers' clubs, debating societies, high school students, boys who drop out of school early, apprentice boys, men in the shops, men and women who cannot leave their homes—how may these and many other classes be given an opportunity to improve themselves either vocationally or culturally? What may be done to increase the intelligence of voters on great questions which are now before the public for solution?

With these questions and many others in mind, the Extension Division has established four main departments of work: namely, of Debating and Public Discussion, of General-Information and Welfare, of Instruction by Lectures, and of Correspondence Study.

To explain the work of the Department of Debating and Public Discussion, I probably can do no better than to quote from an editorial which appeared in the *Boston Herald* of September 26, 1908. This editorial was written after a careful examination of this branch of the extension work.

“Early in November the citizens of Wisconsin will vote for or against an amendment to the state constitution which will permit the legislature to appropriate money for the construction or improvement of public highways. The issue is: Shall the state undertake ‘an economical and efficient system of road-building upon an extensive scale’? Where shall John Doe, who lives in a remote hamlet, or Richard Doe, who lives in Milwaukee, look for information enabling him to vote intelligently on the amendment? To the journalists, politicians and local solons only? Not in Wisconsin. The people have a university which conceives it to be its duty, and its privilege, to furnish information, dispassionate and non-partisan, so far as can be, to all citizens of the state, on every matter of public importance. The people look upon it as ‘our university’. It crowns their system of free public education. They elect its regents. They pay its bills. They know that its investigators have added millions to the wealth of the state. They know that its experts have aided in shaping progressive legislation and in defeating forces that hitherto have been powerful at the state capital.

“And so John Doe writes to the university for information. At once there comes back to him a leaflet, issued by the university extension division and prepared for the use of debaters or voters. Therein he finds the question approached from three standpoints. The wisdom of establishing a system of taxation which compels assessments on cities and villages for roads beyond their limits; the comparative merits of the

New Jersey or the Michigan systems of state aid, and the wisdom or unwisdom of using convicts in building state roads. Reasons pro and con are given on each point. References are made to federal and state public documents which bear on the matter, page and chapter being given. Instructions are given how these documents can be purchased or on what terms they can be loaned. Everything is done to facilitate intelligent understanding of the question. And attention is called to the fact that instruction by correspondence on highway construction and maintenance is carried on by the chief of the highway division of the Wisconsin geological and natural history survey, and also by the university itself.

"It must be obvious that, if referendums are to settle public questions, if constitutions are to be amended during the next decade or two, an electorate aided to intelligent action on the issues involved by those who are above the suspicion of partisanship or of personal interest in the matter will act with far greater wisdom than an electorate which is not so served.

"Possibly a Wisconsin voter may have his doubts whether the initiative and referendum are good or bad devices of modern democracy. He writes to the university, not for an opinion representing its views, but for information as to what is said for the new device by those who believe in it and by those who do not. It costs him but two cents to get his reply. Serial No. 224, General Series No. 25, comes back. In it the initiative and the referendum are defined. The history of the movement in Wisconsin is briefly set forth. Then follow references, pro and con, to the material in the legislative reference department, useful if the seeker be a legislator; or the pamphlets on the subject issued by the states of Ohio and Oregon, which can be had through correspondence. Supplementing these references, page and chapter, to books of general circulation, to arguments by critics and by advocates, and to the literature of propaganda on the subject. Similar pamphlets are to be had on the vexed issues of election of senators by popular vote, the parcels post, postal savings banks, woman suffrage, and proportional representation, and each pamphlet shows how the matter may be still farther followed up through correspondence study with the university.

"Such a system of relating a university to the practical, exigent, political needs of the people, or training them to look to the educated expert for sources of information seems to us splendidly efficient, viewed from a pedagogical standpoint, and in very truth democratic. The institution thereby conceives of the whole electorate as its potential student class, as well as its donor of funds and its sovereign in law."

The Department of General Information and Welfare is designed to form a link between the people of the state and the

National, State and University Research departments. An immense fund of useful information in the form of bulletins issued by these departments is largely latent, either on account of limited circulation or because the publications are couched in language familiar only to the expert investigator. This tremendous force for popular education must be made effective by reëditing in available form where necessary and by wide distribution.

The state commissions of forestry, geology, natural history, the state health boards, the university research departments, the great national societies, are devoted to the solution of problems of universal interest, but their work is not always for the masses. To this extent it is ineffective. Their appeal is to him only who seeks, and the desire to know implies a degree of preliminary knowledge. It is the policy of extension in all its departments of work not merely to respond to demands, but to *create demands* by arousing interest.

As rapidly as means permit, bulletins, monographs, and leaflets on topics of general interest and value are being printed and distributed. For special topics, exhibits, including models and charts, are made up and presented in person by expert demonstrators. Thus, through extension channels, data relating to discoveries, inventions, and all advances in knowledge of everyday interest—which otherwise might lie dormant for years so far as popular use is concerned—will be brought to the people promptly at little or no cost to them, and by such methods as enlist their interest.

As its name implies, this department offers its services to citizens of the state also as an information bureau. Inquiries upon matters affecting private or public interest are answered through its medium by specialists in the university, who also may be sent, upon demand, to inspect conditions and advise as to procedure.

Great care is taken not to encroach upon the field of the professional expert. If the information desired is of such a nature as to bring personal profit to the inquirer rather than general good to his community, he is advised as to the proper

steps to be taken. A short time ago an application for assistance came to this department from the inventor of a machine. The design was given a superficial examination and found to have some features worthy of investigation. The designer was advised of this judgment and assisted in securing professional service.

There are in the United States some hundreds of thousands of men and women enrolled in commercial correspondence schools. These students are working under the disadvantage of distance from the instructor, and in some instances of an almost prohibitive fee. The further discouragement frequently experienced on account of lack of laboratory or library aids, and the loss of class relations is unfortunate. Nevertheless, the great army of those who are urged by desire for learning, but for whom schools are not within the range of possibility grows daily.

The agricultural colleges in many of our state universities, recognizing this hunger of the people, have established extension departments, offering short courses at the institution, traveling institutes, practical demonstrations and correspondence-study. To the unbiased observer, the policy which has led to the introduction in the university of extension methods for the agricultural interests only, would seem to be mistakenly limited. A large majority of the students entered in commercial schools are engaged in technical studies other than agricultural. Trade schools, technical institutes, apprenticeships, industrial courses in high schools and colleges—widespread as these are—are not sufficiently inclusive to meet the tremendous demands for utilitarian education. The need for increased intelligence and fitness in the American wage earner is acknowledged. Skilled labor must frequently be imported and, at best, only certain American products can compete with foreign. The state of Wisconsin is making an effort to meet this condition through the establishment of her University Extension Division for all classes and for every vocation as an organic part of her state educational system. As will be shown, by far the largest application of

the work up to this time has been in the direction of vocational training.

The main advantage derived by the Correspondence Study Department from the association of extension work with the state educational system, aside from that of reduced cost, probably lies in the fact that the student is brought into personal touch with the instructor. In its fullest development this method must eventually lead not only to placing instructors in every part of the state, but in the establishment of local laboratories and class rooms in every community in which they are needed. The traveling library in Wisconsin is closely associated with the work of Extension, and supplies, free of cost, sets of books adapted to the needs of the student or class of students. To facilitate the introduction of extension benefits uniformly throughout the state, the system of organization of which I have spoken has been adopted in Wisconsin, dividing the state into districts, each of which having its complement of organizers, teachers, laboratories, class-rooms, etc.

In order to give you a brief view of the nature of the work offered by correspondence study, permit me to quote from a recent report to the regents of the extension division work:

“Correspondence study may be grouped under several heads, as follows: Regular university grade, special advanced, high school and preparatory, elementary, and vocational.

“The work offered represents 34 departments of the university and includes over 230 courses of study. The subjects taken by correspondence students include nearly all that are offered. The teachers engaged in the work number 74.

“The distribution of students among the more generally chosen subjects is as follows:

Ancient languages—Latin, Greek, etc.....	30
Business administration	122
Commercial law	125
Drawing	194
Education	36
Engineering—electrical, mechanical, etc.....	301
Engineering—shop mathematics, etc.....	492
English	156

Highway construction	144
History—American, ancient, English, United States.....	27
Home economics	17
Mathematics—algebra, geometry, trigonometry, analytical geometry, calculus	213
Modern languages—French, German, Spanish	139
Music—method of teaching in public schools	6
Natural sciences—astronomy, bacteriology, botany, chem- istry, geology, etc.....	63
Philosophy	11
Political sciences—agricultural economics, etc.....	69
Total	2,155
Of these in university grade studies there are.....	551
in high school or preparatory subjects.....	161
in special advanced work	7
in elementary branches	61
in vocational courses	1,375

Up to the present time, less than two years since the inception of this work, one center only, Milwaukee, has been developed outside of Madison. A district representative, two assistants (field organizers) and one resident teacher are now established there. The number of students is increasing so rapidly that it will be necessary to add another resident teacher in the course of the summer.

By far the most extensive and important work in Milwaukee is that conducted among manufacturing employees who engage in correspondence courses with the object of improving their proficiency in the work in which they are employed, or of preparing themselves for more congenial or better positions. 560 men belonging to 20 manufacturing concerns are enrolled in correspondence courses designed to improve their industrial efficiency.

In bringing the university's offer of training by home study to the employee, the firm's management is first approached and with this coöperation, little difficulty is experienced in arousing the interest of the men. There is invariably a certain number in a group of workmen who, upon being shown the way in which they may increase their equipment of knowledge, are eager at once to try it. These have already

desired self-improvement, but have needed direction. Another class of employee is easily awakened to an ambition he has not felt before, and still others follow the lead of their fellows.

Those who are enrolled for correspondence courses are met at once by a teacher who gauges their capacity and preparation and, so far as possible, groups them in classes. It is usually impossible, of course, to form classes, the members of which will work together as do those in graded institutions, but sufficient classification can be accomplished to enable both men and teacher to gain advantage from the association. The teacher meets the classes as often as once in two weeks at least, and individuals who need more frequent and special attention are given it. In many cases thus far class-rooms have been supplied by the management and the men have been allowed time in working hours for class meetings. In nearly every case an arrangement has been entered into by which the fee to the University is paid by the firm from the men's wages.

A remarkable and unusual degree of interest was manifested by one concern which raised the wages of its men in order to enable them to enter courses of study, and paid half the fees of a class of apprentice boys. However, this is only an extreme case. The attitude manifested by employers toward this work has been uniformly encouraging. They believe in its practical value. Business men can hardly be expected to give time from the employee's working hours from purely humanitarian motives, nor would they do so if they were not convinced of the increased efficiency of the men to be gained through education.

Playfair, in 1894, said, in an address on the subject of university extension: "Every man who acquires a taste for learning and is imbued with the desire to acquire more of it, becomes more valuable as a citizen because he is more intelligent and perceptive." Many calculations have been made recently of the actual value in dollars and cents of vocational training. This contention is now so thoroughly accepted that it is no longer necessary to cite results obtained in foreign

countries, notably in Germany, where the continuation school is as universal as any other part of the school system. There seems to be no limit, within reason, to the coöperation that may be looked for from the manufacturer. The prevailing opinion that something is needed in industrial education has made them open-minded. They need only to be convinced that what is proposed is worth while.

I do not wish to be understood to imply that men connected with large business enterprises do not appreciate and value for their employees the enlarged capacity for enjoyment and the mental culture to be gained from their mature studies. In our experience, the interest in the well-being of the men shown by employers in assisting their effort for self-improvement through extension has been helpful in establishing favorable relations between them. In some cases employers have taken an active interest in the men's studies, keeping informed of their progress and assisting the teacher in investigating and, if possible, removing sources of discouragement. The men, as a whole, are making a remarkable record of persistence and enthusiasm. Although many of them are unused to mental exertion and have not been accustomed to conserve their leisure time, but a small proportion of them have dropped work once begun, and some of them have manifested enthusiastic interest, even forming study clubs among themselves, which meet more frequently than their classes, for discussion and mutual helpfulness.

Thus far, neither time nor appropriated funds have permitted more than a limited trial of this extremely interesting experiment among industrial employees, but every firm in Milwaukee to whose management extension methods have been explained, has welcomed the opportunity for its men, and both the reception given the work and the results obtained are evidence of the scope and importance it is destined to assume. In Milwaukee 55,000 men, employed similarly to those already enrolled in the courses of study, have not been offered the privilege. With sufficient time and money there is no reason why many thousands of workmen in Wisconsin may not be

aided by extension to increase their vocational efficiency. The system, worked out to its fullest possibilities, presents incalculable benefits to be derived from the increased value of the man unit and the consequent enlargement of the productive power of industries.

I cannot at this time turn aside to dwell upon the moral value to the artisan of home study, and, indeed, no argument is needed to convince the thoughtful of the usefulness of directed employment during otherwise wasted hours for those whose early opportunities have given no foundation upon which to build a structure of self-improvement. Correspondence study, as conducted by the commercial schools, has vindicated itself in spite of the disadvantages with which it has had to contend; while correspondence study, as a part of the state educational system, is bound in my judgment to rank among the important uplifting influences of the country.

For its fullest success much must depend upon the fitness of the extension teacher. In the beginning, instructors were drawn only from the regular university force. The disadvantages of this practice were immediately apparent, especially for the industrial development. The teacher in extension must possess special qualifications for the work—power to express conceptions in clear and simple language; familiarity with the technical process of the student's employment; tact and such natural insight into character and conditions as will enable him to deal with men; and, above all, his first interest must be in his correspondence study work. Such a teacher, with the coöperation of the superintendent at the works, frequently can do more for the industrial employee than courses of study in trade, or other technical schools. Many of the students of this class are so far removed from their school experiences that they do not know how to make use of schools, even of those designed especially for them. For these the work room, under favorable conditions, is an ideal laboratory and no lesson has meaning which is not expressed in terms of their trade.

It is desirable to keep the Extension Division in as inti-

mate relation with other departments of the university as possible, but for some months past a corps of instructors, specially qualified for this work, has devoted its entire time to vocational teaching. These men are selected in consultation with the heads of departments of resident work, and a persistent effort is made to keep them in touch and sympathy with university thought and methods. Though chosen expressly for extension instruction instructors are occasionally given a small amount of residence teaching in order to keep them closely identified with it.

The problem of laboratory work for correspondence students is solved in a variety of ways. As has been said, the workman's shop may be his best laboratory, but to supplement and enlarge his opportunities the university laboratories are open to him for short sessions of a few days at a time. Local laboratories, also, for special experimentation, will be opened for the benefit of students in classes, as, for example, the proposed fuel testing laboratory in Milwaukee to which the men will bring specimens of coal, ash, etc., from their own plant, in order to determine the economic efficiency of the processes in which they are employed. With the complete organization of the state by districts, permanent local laboratories will be established at the centers, where possible, in public school buildings. This, it is hoped, will contribute to the usefulness and effectiveness of public school work without interfering with the demands of extension students. The latter, indeed, will usually be at liberty for experimental practice only in the evening, and it is planned to use convenient school laboratories, also class rooms wherever practicable. In the meantime the university laboratories and temporary arrangements are depended upon. Apparatus has been supplied by the university for individual study in special cases. Experiments upon local steam engines, boilers and similar machinery, are conducted at the works in which the students are employed with the required additional apparatus from the university in charge of the teacher conducting the work.

I have spoken at length upon the application Wisconsin is making of extension methods in the industrial world. Its work is less comprehensive, perhaps, but not less useful in other directions.

Great care is taken to maintain the standard set by the resident departments with all students for credit. The same pre-requisites are exacted and the work from beginning to end is under the close scrutiny and supervision of resident teachers. I believe I can safely say that in no instance has a student who has taken preliminary correspondence work, failed to make a good standing in his resident studies. The high rank maintained by these students is so uniform as to have done much toward removing the prejudices which at one time existed in the university against the practice of allowing credit for correspondence study.

I need not speak of the value of correspondence study for clubs, to whose use it is especially adapted.

In Wisconsin there are over 600,000 youths under nineteen years of age who are not in schools of any kind. To these the Extension Division offers special opportunities. With field organization as described, and with the coöperation of the public school teachers throughout the state—which is easily secured—these young people may be discovered and an opportunity offered them to take up studies, vocational in character, applying directly to the work they are doing, or to that which they desire to do. Thus correspondence study, supplemented by class work, may establish over the entire state, what would be, essentially, continuation schools. In a word, the University shall fare forth, knock at the doors of the people and offer them—not a hide-bound curriculum, but that which they need.

No mention has been made of the Department of Instruction by Lectures. It is realized that magnificent results in the uplift of the masses is accomplished through this medium. For many years the university has sent out her specialists in science and art, thus contributing to the general culture and enjoyment of the people. As the work of exten-

sion grows, it is designed to build up a great lecture system at nominal cost to the people, which shall coöperate with and supplement the work of the other departments. At present what is done in this direction in our state must be self-supporting, but it is our earnest hope that the day is not far distant when the example of this city (New York) in its great system of public lectures may be closely followed as a development of the university extension work of Wisconsin.

DISCUSSION.

PROFESSOR COOLEY: I would like to ask about what is the average expense to the state for this extension work?

DEAN REBER: Last year the state spent twenty thousand dollars. The legislature has just made an appropriation of fifty thousand dollars for this year, and of seventy-five thousand dollars for next year. The fees amount to from twenty thousand to twenty-five thousand dollars a year and are devoted to the work.

PROFESSOR COOLEY: About how many people will be benefited by that expenditure?

DEAN REBER: We have now about twenty-one hundred students taking correspondence work.

A phase of the work which is especially interesting is its relation to the high schools. The schools throughout the state come to the department of debating and public discussion for assistance in the preparation of themes. This department collects and classifies material on certain questions or subjects. When live topics are up for discussion in the state it goes to the papers for clippings. I refer to such live questions of the day as the initiative and referendum. Another problem which it is taking up is that of the conservation of national resources. By keeping these questions before the public, especially before school children, we can assist in reinforcing and forming sentiment in right directions. No attempt is made to organize societies to work for conservation or other issues. We merely keep these topics constantly before the people so that they may be intelligently advised upon them.

PROFESSOR COOLEY: The work that Professor Reber has described is, in my opinion, one of the most important being done in the United States. The suggestion about the instruction of the child is a very good one. I have been much interested in Wisconsin, and in this extension work of education, particularly during the past few years. I was in Milwaukee last winter for two or three weeks and had an opportunity to learn much about the work of the university. Whenever I inquired about it, I was informed that it was a question whether the university owned the state, or the state the university.

PROFESSOR JACKSON: This is the largest, and in some respects the most comprehensive altruistic effort that is being made by any one of our institutions of higher learning. If one talks with the Milwaukee manufacturers whose employees have been in close touch with this work, one always finds that those employers are deeply impressed by the help they believe they are going to get in the future, from the improved skill and interest of their employees. I was much interested in the early development of this scheme, at least in that part relating to the organization of industrial education throughout the state. I believe that the organization of industrial education cannot be carried on successfully by the ordinary common school teachers or the manufacturers or the professors of education in our colleges. It must be carried on with the cooperation of the engineering teachers, the men who own the industries, and the more altruistic of the great industrialists. The University of Wisconsin can bring this about in its vicinity, not by making industrial education a part of the university curriculum, but by supervising it and seeing that it is broadly organized. The work should not be belittled by being made a fad.

From personal observation I believe that the industrial education part of the organization described in Director Reber's paper is doing great good. While I have no direct knowledge of the other parts of the work, the wisdom of the president and faculty of the university, and the instructors

who have direct charge of the work, is sufficient assurance that they are doing a work that is worthy of confidence and sincerest good will.

THE PRESIDENT: The engineering faculty, which is not connected directly with this work, gives to it its most hearty cooperation. We believe that this kind of work will help the engineering work of the university.

THE FIVE AND SIX-YEAR COURSES IN ENGINEERING SCHOOLS.

BY ROBERT FLETCHER, PH.D.,

Director of the Thayer School of Civil Engineering, Dartmouth College.

This subject is a sequel to a wide range of discussion continued through almost the entire history of this Society. Reference to the sixteen volumes of our "Proceedings" recalls discussions and arguments on: "entrance requirements"; "requirements for graduation"; as to "specialization," what is desirable or necessary; "laboratory practice" (how much, and how should it be correlated to class-room instruction); the separation of preparatory subjects from, or a suitable intermingling with purely professional courses; the vacation question; research work; graduate courses and other topics involved in fixing the limits of the period of instruction.

Whatever may be our ideals or theories, we are facing a situation—a condition of affairs which, among others, has the following aspects:

1. A general acceptance of the four-year curriculum leading to a general or specific bachelor's degree.

2. The necessity, in such cases, of intermingling what are really preparatory subjects—such as mathematics, physics, chemistry, graphics, etc.—with the subjects which are always classed as engineering branches.

3. The questioning of methods and results, prompted by various considerations, among which are:

- (a) The call for more time for the curriculum, due to the extraordinary expansion and outreach of engineering science and practice. Hence the topic before us.

- (b) What may be termed the educational inconsistencies and misdemeanors of our higher institutions of learning and culture (so-called). With all the talk about insufficient time for the needful courses, what are the admitted facts?

The president of an eastern university has been quoted as saying: "Men go to college now for association and sentiment. It is a four-years' playground." There may be some reference here to the obtrusive intercollegiate contests. On the *unpublished* college calendar the usual sequence is: Football, basket-ball, dramatic performances, glee-club exhibitions, spring track-meets for athletics, junior promenade and various festivities, baseball, boat-racing, and lately, in the north, polo. This "traveling show business," in the name of institutions which stand for the highest learning and culture, has the concomitants of notorious betting and the expenditure of thousands of dollars in the travelling expenses of the loyal college "cheering squads." Thus the advantages of sports, allowable in moderation, are lost in wild extremes; thus these distractions from the legitimate work are constant throughout the year; thus some seem to regard this as their chief interest and make a business of play. In another college a professor found, on investigation, that the extraneous activities, such as society matters, college paper, and the various sports and recreations, most of them quite proper and even helpful in their place, might easily absorb all of the time, so as to exclude entirely the real work of the college.

But, we recognize a minority of students who hold aloof from this, in good degree, attend to their proper business, and save the scholarship of the institution. Blessed is the man who has no money for such dissipation; he is not as poor as he thinks he is. It is noteworthy, however, that students of technology are much less affected by this evil; from some institutes and colleges it is entirely absent; and the speaker may add that all who come under his jurisdiction have to renounce all connection with that sort of thing. It is a platitude that the example of the technical schools has revolutionized the programs of the older colleges within a generation; and that their students are prompted to strenuous endeavor, such as is unusual among students in the general courses. Indeed, one college president has commonly said to young men about to enter the engineering courses that they are expected to do about a third more work than the other students.

The extremely hostile critic who recently advised a state legislature to abandon its great university and "go out of the business" of the higher technical education, while showing ignorance of the plainest facts concerning technical education, was taking a distorted view of some features which are undoubtedly open to just criticism.

(c) Questionings on other points have been so well summarized by the president in his opening address that we need not specify more.

4. Entrance requirements is a question which "will not down." The dictation of the universities and colleges to the secondary schools has proceeded to extremes. The protest of the latter has become very loud, both in teachers' conventions and in current periodicals. Studies that belong in college, perhaps to the extent of half a year of time, are crowded back upon the high schools and academies which cannot properly do the work, both because of inadequate teaching force and immaturity of many of the students. A writer in a leading magazine for May has charged the higher institutions with ruining the high schools by diverting their strength and chief endeavors from the many pupils who cannot go to college to the few who can. He says the people, who build and maintain these schools at great expense, are being cheated out of their proper return by not getting the education best adapted to their needs. A few years ago the writer saw an examination paper for admission to our foremost university, requiring solution of a problem in organic chemistry, which the instructors at one academy said would be a hard nut for them and would require considerable time and some laboratory work for a proper answer. Personally the speaker thinks that our committee, in its report not long ago made these requirements a little too high. He would cut out some of the "advanced algebra, any advanced trigonometry and some of the laboratory work." Some of this required mathematics an engineer seldom or never has any use for. It should be relegated to a course set apart for such as wish to specialize in mathematics.

5. As to graduation requirements, or the curriculum itself,

we are coming to something like agreement on the main point. The president of a well-known institute, in a recent paper before this Society on "The Crowding of the Curriculum," made a protest against the tendency to put too much on the program. In this he simply voiced the opinions of many practitioners with which some of us are familiar. They warn us to hold back—not to branch out so much into what are really details, but to do more work on the fundamentals. Professor Perry, of London, has said recently in correspondence with a secretary of this Society: "May I suggest that you Americans are trying to do too much at college. You are trying to teach everything at an engineering college. It seems to me that a college ought to teach a man how to go on educating himself after he leaves college. If this is the aim of a college, then a five or six-years' course is all too long."

6. Our leading eastern university has put this question beyond debate by separating her engineering school entirely from the undergraduate courses and making it wholly a graduate school. Also the oldest great inter-ocean university has recently announced a six-year course with three degrees in sequence: Bachelor of science at the end of four years, bachelor of engineering at the end of five years, and master of engineering at the end of six years.

7. Other institutions have long held to the policy of granting only the degree of bachelor of science at the end of a four years' course, and giving the engineer's degree two or three years later, and only to those who have earned it by proved capacity in professional pursuits.

In what follows the writer distinctly disclaims any implied criticism of any individual or institution, or any assumption that he has found "a better way." The institution over which he has presided for more than thirty years has not suffered from an embarrassment of riches. Its connection, limitations and the high and rather rigid ideal of its founder at once put it in a class by itself. During the first eighteen years of its history it was organized and conducted on the principle of the six-year course—that is two years given to the

engineering courses exclusively, but all preparatory work, including a full course in graphics, gained by a previous college course of four years. Since 1893, the entire period has been reduced to five years by doing all of the preparatory work in the first three years of the college, and allowing properly qualified or picked men to elect the first-year courses in civil engineering as their senior or fourth year work in college, leading to the degree of B.S. The fifth or post-graduate year is then devoted to the advanced courses in civil engineering.

In signing the report of the committee on graduation requirements five years ago the writer added the following comment: "On the basis of hours and exercises which the report adopts as units of measurement, a collegiate course of three years (at Dartmouth College) in languages, mathematics and physical sciences, comprises the following program: Sixteen exercises, equaling forty-eight hours per week, and about 4,750 hours in the three years. After this there is one year of engineering studies specifically, with a degree of B.S. at the end. The thirty-nine actual weeks of fifty-five hours each add 2,145 hours to the preceding. Then a final year of post-graduate engineering study, thirty-one weeks of fifty-five hours each, adds 1,705 hours. The total is 8,600 hours for the five years, with an engineering degree at the end. Between the last two years an interim of nineteen weeks almost invariably devoted by the students to engineering practice more or less remunerative."

It must be understood that the calendar is different from the usual one. The session-year for the first-year engineering students (equals fourth-year in sequence) begins about the middle of July; the work for thirteen weeks is exclusively in surveying with an instructor for each group or section of five or six men. No smoking is allowed during any exercise, indoors or out-of-doors. Note-books are carefully supervised, and checked results required from each individual. In short the sense of personal responsibility is developed in good degree. The fifth-year men do not report until the middle of

September; the school year ends for all with the last week in April.

The men are picked by requiring a proficiency in eighteen subjects, indicated by an average mark of 75 per cent. But the man is also required to make a mark of 85 per cent. in at least three subjects and not to fall below 60 per cent. in any one. This purely mechanical standard is not entirely satisfactory, but it at once excludes a lot of the unfit. Although the entire college record (three years) of each man is available for close scrutiny we impartially give to all an examination which is both written and oral.

The entire separation of engineering courses for the last two years secures some advantages, among which are:

(a) *Continuity*.—Each subject is pursued to the end without a break; not sandwiched in between others.

(b) Only two subjects, as a rule, are taken collaterally. This promotes *concentration* of *attention* or *intensity* of *endeavor*. To facilitate (a) and (b), the unit period is a half day. Under the local conditions of dormitory life and absence of the distractions of a city, the two engineering classes spend a considerable part of each day in the building working under the oversight of the teaching force.

(c) The studies of the first year in civil engineering are so selected that the capable student at the end of the fourth year has a good grasp of the working essentials. The irrepressible self-reliant man with perhaps some previous experience and the engineering instinct, who is always able to keep a little ahead of the others, gets a good start, if he thinks he can do well enough with what he has received. The ordinary man, who perhaps lacks any previous contact with the work, may be advised or required to stay out a year to prove his adaptability to engineering as a career. None are urged to return for graduate work; as a matter of fact more than half do return, and some after having been engaged in practice one, two and three years.

The aim in view must determine our attitude toward the five or six-year course. If we wish to turn out men capable

of being only surveyors, draftsmen, machinists and electricians, it is idle to talk about a five-year course; a four or a three-year course may suffice. But if we want to realize the ideal of an engineer as a man capable of designing as well as directing; a man who can originate, create; who "knows how" to meet unexpected emergencies; who has enough command of his own language to persuade his fellow men, by judicious writing or speech; one not content to be merely the "hired man" of capitalists, lawyers and politicians, but a competent counsellor, capable of filling a receivership, as well or better than one of the legal fraternity; then we must take time to broaden his horizon and give him a larger grasp of engineering and engineering business. We cannot guarantee such results; training for leadership by program in most cases would probably prove a dismal failure, but we can start a man in that direction.

THE FIVE-YEAR COURSES.

BY WILLIAM T. MAGRUDER,

Professor of Mechanical Engineering, Ohio State University.

At the meeting of this Society at Niagara Falls in 1903, a joint session was held with the American Institute of Electrical Engineers. The practicing engineers, by their papers and discussions, required so much of the engineering colleges in the way of subjects covered, that it seemed to the teaching engineers who were present as though it would be impossible to meet these requirements in the usual four-year course. After the session, the writer had the temerity to suggest to a prominent member of this Society that it might be well to extend the courses to five years. His reply was, "Young man, if you want to lose your job, just suggest a five-year course at your university." He may have been correct in his opinion at that time; but if such a statement should be made to-day, it would hardly be taken seriously by anyone acquainted with university conditions.

The term "five-year course" can be properly applied to any curriculum, or course of study, which is scheduled to require five years for completion. Of such, at least four are known.

1. The oldest is the four-year undergraduate curriculum followed by a year of post-graduate study. In many cases, the year of post-graduate study was spread over two years so as to permit the student to earn an income as a teaching fellow or assistant. The work done in the fifth year was usually strictly professional, rather than either cultural or broadening in its character. The degree given was either the master's degree or a professional degree. Statistics will show that less than three per cent. of the students in the different institutions who finished the four-year curriculum returned to take the fifth year.

2. In many of the engineering colleges, and especially those of the Middle West, there are many young men who, having worked at a trade or other vocation and accumulated a few hundred dollars, are extremely ambitious to get a technical education and to make the most of themselves in this world. Not infrequently, their savings are expended before the course is finished, and they either drop out for a year or two, or get a position which will permit them to continue their studies for part time. It has been suggested, possibly by others as well as the writer, that if the regular four-year course of study could be spread out over five years, and the schedule arranged so that students could have their classroom and laboratory work come at consecutive hours, so as to economize their time and permit them to devote a half-day at a time to money-earning occupations, more students would complete the course and fewer drop out for lack of adequate financial means. When a mature, ambitious, and hard-working American student makes up his mind to get an education, it is the part of wisdom, as well as of kindness, to help him on and assist him in his good endeavors rather than to hinder him with technicalities and formalities. Many of our most successful practising and teaching engineers received their early training in the school of self-denial and small means, and did not belong to that unfortunate class of students who are cursed with wealth.

3. In many of the engineering colleges, the established pace proves to be too swift for a number of students who are usually accounted as being slow. This may not be the proper time and place to make an apology for the so-called slow man. The world has been using him for a great many centuries and will probably have to continue to do so. Successful race horses are the exception, not the rule, even when bred for speed. The world has always found use for good, reliable and safe horses; while powerful draft horses which were sure-footed, and capable of carrying large burdens, have always been in demand. In the engineering world, every man cannot be a foreman, superintendent, or head professor. What

the slow man gets, he usually retains with great fixity, and, as a result, he can be depended upon. If therefore, the regular four-year curriculum and the schedule of classes and laboratory exercises could be spread out over five years for him, in a way similar to that best suited for the student who has to earn his income as he spends it, more students would be graduated and the world would be better off on account of having a larger number of well-trained, steady-going, and reliable men on whom to draw. If a student is only slow, and neither lazy nor stupid, he will, as a rule, well repay the thought, guidance, and efforts of his professors and adviser.

4. For many years it has been felt that the present curriculums of our engineering colleges were too specialized and that they needed to be broadened, and that we were turning out a fairly efficient engineering product, but one not adapted to a variety of conditions. Efforts to broaden the course of study and to inject more culture into it have been met by indifference, and even by opposition, from the conservative professor of the academic college. So far as known, Harvard University is the only institution which requires a bachelor's degree from an acceptable institution as a requirement for admission to its regular course of engineering study. At most colleges and universities, it is thought that seven years of a man's life is too much to give to his collegiate training in engineering, and hence courses of study covering the regular course leading to the degree of bachelor of arts and supplemented by one of the regular engineering courses, and requiring from five to six years for completion, are now being offered in a dozen or more of our universities.

It fell to the lot of the writer to be appointed chairman of a committee of the university faculty of the Ohio State University charged with the duty of investigating the question of combined courses of study leading to two degrees. It is thought that some of the information obtained may be possibly worthy of recording by this Society.

Opinions on this subject were obtained from the presidents of some twenty-one institutions, either in the form of per-

sonal replies in answer to a set of eight questions, or of reports on the subject made to their faculties or to their boards of trustees, the personal replies from twenty-eight deans to the same list of questions, and the statements in the catalogues of about twenty-five institutions, together with papers dealing with this subject, which have been presented to educational associations. This large collection of evidence and opinions was codified by questions, or by subject matter. The excerpts made therefrom formed a report to the committee of some one hundred and fifty pages of type-written matter. From this report the following conclusions can be properly drawn.

There is an increasing demand for an education broader than that of the usual so-called professional curriculum in engineering, and yet more specific than that offered by the usual academic curriculum. This demand is being met by students taking either a combined curriculum leading to two degrees, or by taking two curriculums one after the other. That where publicly offered and scheduled, or when openly advocated and urged by the leading members of the faculty of the professional curriculum, such combined curriculums leading to two degrees are of increasing popularity. That the longest time required for the combined courses of study is at Harvard, where it is seven years for Arts and Engineering. One institution confers a bachelor's degree at the end of the third year and a master's degree at the end of the fourth year. This is the only case found of two degrees being given for a four-year course of study, and was not in engineering. It has been found that if the first three years of the combined curriculums are taken in the academic college, the work of the engineering college can be completed in three additional years, or in a total of five years including work in the summer terms. That arrangements have been made between different institutions in the same state whereby work at one will count towards the degree from the other. That to complete the work required for the two degrees in six years, or in five years and summer terms, concessions

must be usually made by one or the other of the faculties granting the degrees, and usually by the faculty of arts and sciences, as it is recognized that the professional work cannot be so easily curtailed in amount and must be more definite and specific. That combined curriculums could be more frequently taken if the students knew their minds and could map out their curriculums beforehand, and if the professors in mathematics, languages, drawing and the sciences knew in detail the kind and character of instruction which was desired for the student by the faculty of the college offering the professional curriculum. That students migrating with advanced standing from one institution to another are frequently handicapped in getting credits which they might have obtained if their work had been chosen more carefully and to meet the requirements of the professional curriculums. That the faculties of the institutions whence these students come would be better pleased if migration could be deferred until the end of the third year; and the students would be more likely to stay through the third year if it were known that the degree in arts and science would be awarded by the first institution on the satisfactory completion of the first year of the professional curriculum elsewhere. That an increase in the number of undergraduates in engineering who had been trained in arts and science would improve the average of the upper classes of our professional curriculums, would tend to raise the standards of scholarship, would tend to make the professional curriculums less technical and industrial, and would set the example to the students of taking more cultural work before beginning the professional course of study. As a result of this, the various institutions would come into closer relation, would understand and appreciate the better each other's aims and standards of work, and a more kindly feeling would be engendered among the undergraduates. The existence of a body of alumni having degrees from two institutions would tend to keep down animosities and jealousies, ill-will and bad feeling.

It is quite possible that certain of our engineering colleges

may not be able to get the sympathetic coöperation of the academic colleges in their desire to inject more culture into the present engineering curriculums. In this case, it may be necessary for the college of engineering to offer courses in the desired culture subjects as part of the regular undergraduate curriculum in engineering which will then have to be of five years' duration.

THE LENGTH OF AN ENGINEERING COURSE.

BY CHARLES DERLETH, JR.,

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At the University of California the engineering faculties have been studying this question earnestly for at least three years. During the past twelve months our academic council instructed its committee on engineering curricula to give the subject special attention and a report was presented in April, 1908. The question of lengthening the period of engineering training is a subject of keen interest. Representatives of our leading institutions have been expressing themselves frankly about it. Such statements as President Schurman's in his presidential report to the board of trustees of Cornell University for 1906-7, pp. 52-59, are not merely expressions of individual views. The idea is in the atmosphere. Everyone intimately connected with the problems of engineering education is thinking of the subject.

The University of California is the keystone of our state public school system and for many years has coöperated with the schools in shaping and developing the courses of high school instruction. Our matriculation entrance requirements have greatly influenced the subjects offered in the schools, particularly the high schools. We find, however, that it would be unwise for the university to insist upon a rigid or specific entrance requirement even if it had the power. Our high schools exist primarily for the instruction of that larger body of students who do not avail themselves of the opportunities of a university course. It must be admitted that an important, if not the most important, function of the high school is to train men and women for the ordinary pursuits of life. It is only the minority of high school graduates who apply for admission to the university. It has become very apparent

that an adjustment should be made; that our entrance requirements for the several colleges should not be too rigid, but give some leeway so that students would not be too severely handicapped, if at the last moment in their high school course they decided to go to the university, or if in the last year they concluded to enter a different department from that at first considered; an engineering school, for example, instead of the college of letters. Moreover it would be unjust for the university to insist upon so rigid a system of entrance requirements that the high school, in order to prepare the minority of students for entrance to the university, would be forced to shape their four-year course for these students entirely at the expense of a program best fitted to the needs of the larger majority of high school students who never intend to enter the university.

During the academic year just ended, a committee of our faculties has been at work on the problem of our entrance requirements. The committee was appointed in May, 1907, to consider the requirements for what we term the "junior certificate" and to present a plan for the unification of university instruction. The plan outlined adapts itself quite readily to our so-called culture departments; namely, the colleges of letters, social sciences, natural sciences and commerce. The report of the committee proposes a uniform system of entrance requirements for all these colleges instead of the separate lists of requirements which heretofore have been in force.

Upon entrance to the university the student continues his studies for two years, at the end of which time he receives the junior certificate, provided he has completed 109 units (including entrance). Of these one third are elective.

These requirements allow of considerable elasticity, so that a student is not forced to determine completely upon his later university program while still engrossed with his earlier high school studies. The system furthermore gives considerable opportunity for transfer from one college to another. In our culture colleges the junior certificate marks

the separation between "lower" and "upper division" work. A student must obtain the junior certificate before beginning his upper division studies. The upper division concerns what is commonly called the junior and senior years. A student must be in residence at the university at least two years after receiving the junior certificate before a bachelor degree is granted. The lower division years of the university, that is the freshman and sophomore years, are looked upon as the final years of a six-year high school course. We sometimes speak of these two years as comparable to college work in distinction to upper division or university courses. The requirement of the junior certificate and the uniform plan for matriculation are intended to produce a sequence and inter-relation of studies for a period of six years beginning with the student's graduation from the grammar school. The advocates of this plan believe that with proper coöperation between the high schools and the university (with wholesome advice from our university study lists committees) students will not be obliged to determine in the first or second year of the high school which course or college they intend to enter at the university, leaving the freedom of choice to later years.

I have referred in some detail to this report of our committee on junior certificate because some members of the committee seriously proposed the direct application of the scheme to the colleges of engineering, in order that a uniform scheme of instruction might obtain throughout the whole university. Moreover, it was intended to make thereby possible such a freedom in the so-called six-year high school course that a student might transfer without serious loss of time from a course proposing to graduate him from the colleges of letters or social sciences to a course in one of the engineering colleges, or vice versa. The committee further wished to introduce into the curricula of the engineering colleges a minimum amount of cultural subjects such as English, foreign languages, history and economics, so that our engineering students in receiving the junior certificate at the end

of the first two years of the university course might have a training reasonably comparable to that enjoyed in the so-called culture colleges.

In these deliberations many obstacles were met by the junior certificate committee. It became clear that a solution of the difficulties could not be obtained with a four-year engineering course. As a compromise the committee reported to the academic council that the four-year engineering courses as then existing (April, 1908) be continued with slight modifications and that an alternative five-year course be offered, adapted to the uniform matriculation requirements, and involving the principle of the junior certificate with a requirement of at least eighteen units of cultural subjects in the first two years of the course.

According to the plan proposed by the junior certificate committee it would be possible for a student to enter the university with a much weaker matriculation requirement than formerly. A student might enter the first year at the university lacking credit, for example, in chemistry or physics, in free-hand or mechanical drawing, or in the later mathematics. The committee argued however that the elective system in the first two years would enable the student to satisfy these deficiencies; but it is clear that the student could only make such satisfaction at the expense of the university mathematics (particularly calculus) and advanced subjects in chemistry and physics usually found in the freshman, and particularly the sophomore years of an engineering course. Inevitably, as already stated, such students would be required to remain at least five years at the university, particularly when it is contemplated that in addition the student must complete at least eighteen units in advanced English, foreign languages, and history or economics.

That such a system of instruction has its advantages no one can deny but the technical instructor realizes the great value of the student's time and appreciates the seriousness of the situation where a student enters his profession at too late a period in life. I believe that at least one year of the student's

time is lost or wasted in the grade schools and high schools. One of the serious problems which must be considered now in this country is the improvement and compression of our grade school and high school courses so that either the student may be graduated one year earlier or be graduated at the present average age having, by more intensified study, completed a larger and more inclusive number of subjects. The entrance requirements to an engineering school must be relatively rigid. Mathematics, physics, chemistry and drawing must be represented. It would be a mistake, at the University of California, to encourage the introduction of a loose matriculation requirement containing a large election simply to unify the requirements for all the colleges.

Our strongest students should be allowed the opportunity of graduation in four years provided they complete a heavy course, including a relatively large number of units per term; for example, seventeen or eighteen units per half-year (where a unit represents either a one-hour lecture period or a three-hour laboratory period per week for one half year). Engineering subjects, when treated in a broad way, have a distinctly cultural value. By their work engineering instructors must prove this principle, maintain its effect, and establish its truth. Moreover, they must go out of their way to convince their brethren in other or humanitarian departments of university instruction. Certainly it is to be desired that a student in engineering take courses in culture subjects, but the question at issue is one of expediency. Is it better for the average student to consume an additional year in culture work, or is it better for him to pursue a four-year course, developed in a broad and cultural way, despite the fact that the subjects are mainly technical, thereby giving opportunity to use the fifth year in the beginning of his practical work in engineering?

In many respects the engineering profession differs in its university training from that of other professions. For the profession of teaching or of astronomy, for instance, it is right to expect that most of the student's work shall be done

at the university. Advanced work in engineering can best be done in practice. Except for the few, the student's graduate laboratory in engineering is outside of the university. It is a question whether an engineering course should be extended from four to five years either to introduce cultural subjects on the one hand, or advanced technical subjects on the other.

In the light of the proposals of the California committee on junior certificate, our more specialized committee on engineering curricula presented last May to the academic council alternative four and five-year courses in engineering. These were approved by the council and went into effect in August, 1908. It remains for experience to determine the effect of these alternatives. It is probable that the majority of students will attempt the four-year course. It is certain that only the strongest students can be graduated from it in four years. In either the four or five-year course it is practically necessary for a student to apply for admission with the old matriculation requirements. Should a student apply with more meagre requirements, that is, with less mathematics, science or drawing, he will require more than four years for the four-year course and more than five years for the alternative course. Students attempting the four-year course and failing to satisfy it, will naturally take four and one half to five years. Their study lists committees, it is hoped, will encourage such persons to avail themselves of their opportunities to elect cultural work for the hours left free in their expanded schedules.

Without definitely requiring every engineering student to be in residence for five years, we believe that we have made a distinct step in advance. With the existence of a five-year course it will no longer appear a great hardship or stigma for a student to remain at the university for five years. The tendency will be less acute for "conditioned" men to bring every conceivable pressure to bear to be allowed to attempt graduation in four years by an overloading of subjects in the later years of the course. Our five-year alternative courses

distinctly recognize the desirability of cultural work; they request a selection in the first two years of at least six units of English, six units of foreign language and six units of history or economics; a total of eighteen units. They demand this selection if the student desires to obtain the junior certificate. Both the four- and five-year courses admit of considerable election, particularly in the later years.

Personally I believe the five-year course a better one than the four-year scheme. I should hail it at our university with the greatest pleasure if at the same time it became possible so to compress and intensify the grammar school and high school studies that students would enter the university at an average age of one year younger than at present, still offering our matriculation requirements as they now exist. I hesitate to add a year at the top of an engineering course for the average student. I do believe a five-year course better than a four-year course and should like to insist upon a minimum of, say twenty units, of cultural subjects. A five-year course in the university has the further possibility and great advantage of offering to the student two years of study following the completion of analytic mechanics. Calculus should be the feature of the second year's work with analytic mechanics and strength of materials as the dominant courses of the third year. The engineering members of our junior certificate committee have attempted to impress this relationship upon their fellow members. We believe that the separation between so-called upper and lower division work in engineering comes with that stage of the student's studies where he has just completed the calculus and is ready to begin the analytic mechanics and strength of materials with their attendant subjects. Logically therefore, at least in the judgment of our engineering instructors, the so-called junior certificate would come at the close of the third year of the five-year engineering course and not at the end of the second year. This discrepancy has made it impossible to bring about, for the present, the complete unification of university instruction which was contemplated by our junior certificate committee.

Whatever the outcome of our new alternative curricula it is clear that our best students will require but four years of residence. We confidently believe that we can leave to them the question of cultural training. The stronger engineering students will get that training from broad engineering courses as well as from strictly humanitarian subjects. They will continue to be students after they leave college. Our weaker students will be required to attend the university five years, whether they begin with the four or the five-year course. Some of our strong students will stay five years by preference. Perhaps we may soon find it desirable to insist upon a five years' residence as a minimum requirement for all. When that time comes let us hope that the intensification and consequent increased efficiency of the grade and high school instruction will bring to us pupils of a younger average age so that when our technical graduates leave the university they will not be much older than twenty-three years.

DISCUSSION ON FIVE AND SIX-YEAR COURSES.

DEAN WILLIAM G. RAYMOND: In connection with the discussion of five and six-year courses in engineering, I shall present, for record, a statement of a new course that has been established by the College of Applied Science of the State University of Iowa. This course, which is called a general engineering course, has been established to provide, first a broad basis for a five or six-year course in engineering; second, a four-year college course in engineering for young men proposing to engage in industrial business, or, indeed, in business of any kind. All incoming students of engineering are advised to take this course if they feel they can give five years to their college work. The course does not take the place of the regular four-year courses, in engineering, in each of which all the work is prescribed. These are still offered to those students desiring the narrower technical training. The general course is advised because it furnishes a much broader training for business, as well as the profession of engineering, because the engineer who combines a sound knowledge of mechanical principles with a comprehension of the larger questions of business management, makes the greatest financial success for himself, and is of the greatest good in the community.

The freshman year in engineering is alike for all students. There are slight differences in the sophomore year among the courses arranged for civil, mechanical, electrical, mining and chemical engineering students, and somewhat greater difference in the junior and senior years. In the general engineering course, the first year includes the regular prescribed work for all engineering students; the second year, the work prescribed in some one of the several branches of engineering; and in the third and fourth years thirty-four credits out of seventy-two, are prescribed. A reading knowledge of one foreign language is also required. The remaining credits,

numbering from ten to twenty-eight, according to the language requirement, are electives, to be chosen from courses given in the College of Liberal Arts, the College of Law, or the College of Applied Science, with preference given to courses in economics and law.

The credits that are required to be earned in the College of Applied Science during these last two years, are thirty, five each in theoretical mechanics, materials of engineering, hydraulics, stresses in structures and machines, steam engineering, and electrical engineering. Courses in physics, chemistry, descriptive geometry, drawing, shopwork, surveying, mineralogy, geology and so forth, are included in the first two years. At least ten credits in English are required before graduation. The degree offered upon the completion of the general engineering course is bachelor of science; the degree offered upon the completion of one of the four-year engineering courses is bachelor of engineering. The degree to be given to the student who completes a five or six-year course, with this general course as a basis, is not yet determined.

It is believed that this plan of carrying regular four-year engineering courses, and this somewhat broader course, which shall serve as a basis for a five or a six-year course, is, for the present, a better plan than would be the adoption of regular five or six-year courses for all engineering students. It has one characteristic that may be considered a disadvantage, or an advantage, according to the viewpoint, namely, that a student may, by choosing possible electives, secure all of the training that is given in some one branch of engineering, in which he may thereafter specialize. This is perhaps not a disadvantage if, to secure this training, he does not sacrifice language, economics and law, and yet it is a question whether or not it is a disadvantage for any student to specialize in any one branch of engineering work in an undergraduate course. While a man must, in the course of time, become a specialist in some one line, it is true in engineering, as in medicine, that he is the best specialist who has a knowledge of the entire field.

The main question in education is not one of years, but rather of the men we are teaching. We are not manufacturers; we do not make engineers. They are born, anyway. We do not make character. We are more like gardeners. We put the soil around the plant and if the latter is a weed, it will grow luxuriantly and become worse, perhaps, than if we had let it alone. If it is a good plant, it will improve by the training. In the School of Applied Science of the State University of Iowa, we have one man whose experience makes us question the wisdom of the experiment. That man has succeeded in graduating at the head of his class in three years, completing all of his work. Further, he won a prize of one hundred dollars for the best undergraduate thesis. He supported himself during school and was married during last year. He has fallen into a twelve hundred dollar position at the start and is at present the best assistant his employer has had for years.

PROFESSOR NORRIS: The faculty of Sibley College, at the suggestion of President Schurman, has been making a study of the five-year course. As a result a new five-year course is just about to go into operation. A student, if he desires, may enter the College of Arts and Sciences, with Sibley College in view. While he enters the College of Arts and Sciences as a regular student, he does so with the privilege of electing certain specific studies which will later assist him in the study of engineering. For the first two years, he is under the jurisdiction of the College of Arts and Sciences and Sibley College has nothing to do with him except to give him instruction as prescribed by his faculty. At the end of this time, he enters Sibley College if he wishes to, or continues in the College of Arts and Sciences, in the latter case taking the A.B. degree at the end of the four years. If he enters the College of Arts and Sciences, with Sibley College in view, and after two years transfers to Sibley College, he receives the degree of M.E. from Sibley College five years after matriculation. He takes a special course which more and more closely approximates the regular course, until in his fourth

year (the third year of the regular students) when he and the regular students are again together and graduate together. The purposes of this plan are several. First, if the course becomes popular, there will be a relief of the pressure upon the high schools. The high schools of the state will lose some students, but they will be able to attend to their natural functions as high schools rather than as preparatory schools. Second, a student may enter the university a year younger, and take in the university certain mathematical and scientific studies, which can be taught better by the university than by the high school. Third, there is an opportunity for liberal culture which is largest at the beginning of the course. This is the time when such studies can be best appreciated.

DEAN COOLEY: At Michigan we inaugurated last year a new extended course, the "six-year course." This is in addition to the old four-year course which leads to the degree of bachelor of science in civil engineering, mechanical engineering, etc. In this new course, at the end of four years, the student receives the degree of bachelor of science in preparation for engineering. And at the end of five years, he receives the degree of bachelor of civil engineering, mechanical or electrical engineering, and at the end of six years, the degree of master of civil, mechanical engineering, etc. We thus have four courses which lead to four distinct degrees in the ordinary branches of civil, mechanical, electrical, chemical and mining engineering.

My impression is that there are from twelve to twenty men already registered in the six-year courses. These are taking the course leading first to the degree of bachelor of science in preparation for engineering. We look forward to the gradual disappearance of the old four-year course, and the general adoption by the students of the broader six-year course. The differentiation lies in the addition of culture studies to the early part of the curriculum.

In November, 1909, the regents of the University of Michigan changed the degrees in the department of engineering as follows:

On completion of the old four-year course, the degree of bachelor of civil engineering, mechanical engineering, etc.

On completion of four years of work in the six-year course, bachelor of science in civil engineering, in mechanical engineering, etc.

On completion of five years work in the six-year course master of science in civil engineering, mechanical engineering, etc.

On completion of six years of work in the six-year course, master of civil engineering, of mechanical engineering, etc.

This order is considered more logical in that the degrees conferred on completion of the old four-year course and on completion of the six-year course are more technical than those conferred at the end of the fourth and fifth year of the six-year course.

PROFESSOR CRANDALL: I wish to supplement somewhat the remarks made by Professor Norris, by stating that the five-year course in civil engineering in Cornell University is similar to that of mechanical engineering in so far as the general requirements are concerned. The entrance requirements are really advanced rather than lowered; that is, the total preparation for them. The difference being that specific subjects are not required. The present four-year courses, both civil and mechanical, require advanced mathematics. We have always a number of students applying for admission poorly prepared in these subjects. By taking the five-year course these students can take advanced mathematics in the university. We hope thus to get better preparation in advanced algebra and trigonometry, and to get time for culture studies in addition.

PROFESSOR HIBBARD: In the University of Missouri, we have taken a step more radical than any thus far mentioned. We are not going to wait to see whether a five-year course will be popular or not, but beginning with September, 1911, we shall abolish the four-year course in mechanical, civil, electrical engineering, etc., and for it substitute a five-year course comprising two years in the College of Arts and Sciences,

followed by three years in the School of Engineering. At present and for the next two years the granting of the degree of bachelor of science in each branch of engineering will be continued. Beginning with the students entering in September, 1911, the degree at the end of the five-year course will be the full engineering degree.

PROFESSOR MUNROE: The combined (and shortened) course of collegiate and engineering studies, in which the two degrees, baccalaureate and professional, may be obtained by seven years' study, has been in operation at Columbia since 1890. The six-year course for the two degrees was inaugurated in 1897. The origin of these combined courses is as follows:

About twenty years ago Columbia College adopted certain essential subjects as the basis of a liberal education. These required subjects are: English, French or German, Latin, history, mathematics, philosophy and some one branch of natural science. Outside of these required subjects a broad election is allowed, at first in the senior year only, but now in any year of the college course. It is evident that it is quite possible to combine these essentials of a liberal training with the required engineering studies without making it necessary for the student to spend four years in college and four years in a professional school. From the standpoint of the college, such a combined course is justified, as a large part of the engineering studies are of a collegiate character. From the standpoint of the professional school, such a combined course has the advantage that it secures a larger proportion of liberal studies than is practicable in an engineering course of four years. This idea received at once the approval of President Low and other prominent educators, including President Butler; it was endorsed by the university council and finally went into operation in 1897. The plan is styled in certain educational circles the "Columbia Plan." It is interesting to note how far this plan has spread and how generally it has been adopted. Since 1897 the combined course at Columbia has been taken each year by an increasing number of students. At present it is possible to obtain the essentials of a liberal education and the

training for a professional degree in six, seven or eight years, as the student may elect, so that he may take as much or as little liberal work as he may desire.

An objection has been urged against collegiate preparation for work in the professional schools in that college life tends to unfit men for serious work. There is some ground for this criticism and we have endeavored, in recent years, at Columbia to encourage men in various ways to do better work in the college. It is now possible for students of Columbia to obtain the first degree in three years by gaining additional credit for good work and by taking a certain proportion of their studies in the summer session.

PROFESSOR CARL C. THOMAS: At the University of Wisconsin there is a considerable number of students in the five-year course. It is the general feeling among faculty and students that the course is one affording great advantages over the four-year course, and that it will develop so as to attract a large number of students. It seems unfortunate that a student should spend four years in a place where there is such an unlimited field open to him as there is in a university, without becoming acquainted with more than a little corner of the field. A five-year course gives him an opportunity to explore to some extent the educational fields of the university, and to get a much more general benefit than is possible if he confines himself entirely to the requirements of the technical courses.

By far the greater number of students take the four-year course, and it is impracticable to give those men opportunities to work in many of the subjects that they should know something about. There has been at the University of Wisconsin a tendency to develop seminars for general discussion, attended by thirty or thirty-five men. Members of the faculty attend these seminars, and the subjects discussed are not confined to engineering. In one seminary held during the past year, all sorts of subjects have been taken up. We have brought into these seminars men from other departments of the university, and also men from the active engineering field.

Parts of our two-hour sessions have been devoted to reports by students or by members of the faculty. We have had discussions on all sorts of subjects, from ethics, biology and higher mathematics to lumbering on the Mississippi River, and the best methods of handling live stock in cattle cars.

MR. KENT: This agitation of five and six-year courses in engineering schools seems to be a fashion or fad that is coming in. I have been trying to find out what it all means. One party says we want to give our students a more liberal education, combining the liberal arts course with the engineering course, and turning out the engineer a more liberally educated man. Another takes the ground that the engineering courses themselves require more than four years. Engineering is becoming so complex, they say, that we cannot teach it in four years, and we must have five or six. Still another says that we must have five-year courses because the high schools do not prepare the students well enough. We have to take an extra year at the bottom of the engineering course in order to give the freshmen what they should have had in the high school. There thus seems to be no unanimity of opinion, among those who have advocated the five-year courses.

It might be well for us to get together to find some uniform basis upon which the essentials of the course may be worked out. Does the five-year idea mean that we must have a more intensified five-year technical course so as to give a working knowledge of wireless telegraphy and wireless telephoning, and a lot of other new things; or must we give a year or two to some fastidious intellectualism, some more intellectual culture? In the latter case we can give some more French and German, some economics, some higher English (not ordinary common-sense English, but Anglo-Saxon, for instance), to give what some call more broad culture.

President Schurman, in the report previously referred to, said that it is unfortunate that we have no definition of what broad culture is. No two men will agree on a definition, or on a list of subjects the student should acquire. Take, for example, the boy who comes from the farm and the district

high school. He enters the engineering course because he thinks he would like to be an engineer. He hears that engineering is a very good thing, and that lots of money may be made in it. Shall we give this boy a preliminary year of "broad culture" and thus lengthen the course to five years, or shall we distribute a year of "culture" along the five-year course, or shall we give him a post-graduate year in engineering after the usual four-year course? I think it is well to let the student realize that the most important post-graduate course he can get is in the shop; that a post-graduate course in college is not as good as a post-graduate course in the shop with overalls on. He will learn more in one year after he gets out of college at twenty-two years of age than he will learn as a post-graduate student taking two years more of professional work in college.

I have just had an experience with a young man who graduated two years ago. I urged him to get out of college. He said he thought he would take a post-graduate course as he enjoyed college life very much. He had distinguished himself in athletics, and liked to belong to the musical society. He really enjoyed college life; he is the kind of fellow who knows how to enjoy life. He was a good student and a tip top fellow. He had a great deal of education in him, and had educational ideals. I urged him to get out of college and take an apprenticeship course, but he would not. He stayed in college and took some experimental course, and to help himself along became an assistant in reading quiz papers, etc. After a year or so of post-graduate work of that kind, which did not advance him in the slightest, he left the college. He wrote me a few days ago to say that he has had hard lines, that he has finally gone back to the farm and has begun life anew, doing something that will not help him in engineering work at all. Now he writes to learn if I can find him a job. I found him one, and I hope that he is at last to take the engineering apprenticeship course. He has to start just where he might have started two years ago. He has really lost two years by taking up this post-graduate course, in order to stay that fifth year in college.

PROFESSOR FLETCHER: I have watched graduates from Cornell for many years. My own observation is that the men who were ripened up pretty well when they left turned out much better than the men going out too young. Those men were men who had ripened up quite a little before they came, and were mature when they left. We have had, and I have in mind now, men who did not like practical work, who have tried to get off rather than stay and take the additional work. I think that that class should be recognized.

My own observation is that the man who is fairly mature when he enters is the man who turns out the best. That is because his education is a good deal of a ripening process, as well as a process of instruction in college.

MR. CHAS. F. SCOTT: There seems to be one fairly uniform panacea for the difficulties in engineering education. Sometimes the criticism is that the course is not broad enough; or that it does not contain certain subjects; or that it ought to be more technical; or again, that it ought to deal with commercial matters, teaching men to be managers or cost-keepers. But whatever the complaint, the usual solution of the problem is simply to extend the course. It is so much a matter of credits, hours, years, of so many things to be learned, that we almost lose sight of what we really want to do. It is not primarily to teach the boy things, but it is to prepare him for his life's work.

A few years ago a professor brought to me for criticism an outline of a proposed engineering course. There were only a few hours allowed for anything except purely engineering or mathematical subjects leading directly to the particular branch of engineering. I said, "You ought to have more general culture, history and economics right along through the course." He said that he would then have to leave out something. When I said, "Then leave it out," he replied, "Then we would not be on a par with the other schools. I have gone through many catalogues and found what they all have, and we must have everything that I have put in the course if we wish to be on a par with the others." This indicates that

there is a kind of competition as to the number of subjects which can be squeezed into these courses. Naturally they get filled up or are extended too much. There is a kind of artificial filling up in an attempt to get all possible topics into the course. It is all wrong to try to teach a large number of specific branches of engineering, with a view to preparing a man for expert work immediately after he leaves college. That is not what the college is for. The graduate will learn in these lines more in the first few months of actual practice than he can learn in college, and he will learn it a great deal better. There is great danger lest we try to make an engineering trade school out of the college course.

Some of the remarks made this afternoon were most excellent. One was that the object of the college course is to make men good climbers, to make men who know how to keep on developing after graduation. The remarks of Professor Thomas struck me as being most timely. The seminaries in which some little presentation is given of the different branches of engineering are excellent. We want to give students some view of the different departments of engineering, so that they will recognize something of what is there, and also that they may appreciate fully that they do not know all that is in those subjects.

The five-year course seems to be an easy solution of two present problems. One, the enlargement of the engineering course and the other the introduction of culture studies, which we certainly need. The real problem, however, is not one of the length of the course, but rather of the way in which it is taught. Effective teaching is the first requisite. The prime purpose of the college course is training. More depends upon the teacher than upon the subject. Almost any branch of engineering can be so taught that it gives good training in English and in logic. One of the best courses I ever had was in geology, not because I learned anything in particular of the details of the subject, but because I was in contact with a great teacher—a man filled with enthusiasm and with scientific spirit.

Engineering training ought to be the development of the natural instincts in a boy. If we delay engineering training until after the formative period, if we teach first the broader subjects in the general course, we may delay too long the training of those natural instincts. The industrial school in connection with a manufacturing company, has the great advantage of developing the natural engineering instincts in a boy, keeping them alive and active, while his education is going on. In making the course longer, we run the danger of delaying too long the scientific and engineering training. Further, if our college course is continued too long, we run into the difficulties of which we were warned this morning, particularly by Mr. F. W. Taylor, that the longer we keep the boy in college, the more we get him away from the ordinary channels, the less adapted he is to take up his life's work and the more of a struggle he will have afterwards.

Hence, in order that the five-year course may be worth while, there must be a broad and continuous development, and it must be along lines which will better and better fit the student for his life's work.

PROFESSOR WALDO: We are agreed that the success of our engineering schools has largely arisen from the fact that they have met the need which was expressed by the people at large. If we get away from that sort of a call, and begin to figure up among ourselves what we would like to do, rather than what we should do to serve the public, we may go astray. If my experience teaches anything it is that there are few young men coming to our technical schools who can afford to spend more than four years in their college course. If we unduly extend it, we either keep them out of the college course or we drive them into some other kind of course. It is evident that our technical schools have stretched their hold upon the young men about as far as it will stand at the present time. If we add a year or two to the course there must be a very definite reason behind it. If we say that our students are coming up to our institutions less and less mature to undertake the work that we wish them to do, and

that, therefore, it is necessary for us to give them an additional year of training in the colleges, and thus make the course five years, seems logical. But if we agree that our secondary schools are doing their work better and better, so that at the end of four years of secondary training our boys to-day are better off than they were ten to twenty years ago, and if we agree in addition that we must give them five years before we put them into active work on the outside, are we not possibly making a mistake?

We ought to have a committee to work upon the statistics of this matter. There has been much said about the popularity of the five and six-year courses, but nothing very definite with reference to the number and character of the young men electing them. Are they young men who are going out as active technical engineers, or are they young men, for the most part, who expect to become teachers. Some of those who are advocating the five and six-year courses, as at Missouri University, have burned their bridges behind them and distinctly say that after a definite time a compulsory five-year course will be established. It will be interesting to see what the effect of that five-year course will be upon the number of students entering the engineering department. At the University of Minnesota, the five and six-year courses have been entered upon with the clear understanding that the number of students will be greatly diminished, and they are ready to face that proposition. At the same time, it is a question whether or not an institution is serving its state as well by putting up such barriers against the completion of a four-year course for a student, as it would if it definitely gave its credentials after four years.

I do not want to protest against the five, six, seven, eight, ten or twelve-year courses, but I do feel that we are possibly making some mistake, and that the statistics of our engineering education in the near future will show that if we enlarge our courses and demand more years of our young men before sending them out with our full credentials, we are going to diminish unduly the number of well-prepared students who

take our engineering courses, and thus diminish the influence and usefulness of our engineering schools.

If our engineering schools are now overrun with students and the authorities who are responsible for these schools are unable or unwilling to provide adequately for their support, isn't it better to make the quality of candidates for admission higher by examination in a few important subjects or by early exclusion of larger percentages from the freshman class after one or two months' trial have shown that the work of preparation in essential respects has not been well done?

DEAN RAYMOND: For purposes of record it should be mentioned that Washington University established a five-year course in engineering, in the middle eighties. It was afterwards abandoned, for what reason I am not informed.

PROFESSOR WILLISTON: May I suggest that, in order to make this discussion of the five-year courses complete, and as accurate as possible, all of the institutions that have been referred to as having had five-year courses furnish the incoming secretary with a sentence or two of information as to the proportion of engineering students who are enrolling in these five-year courses; and also whether or not the five-year courses are intended to eventually supplant the four-year courses. We shall thus know whether these new courses which are being added are off-shoots or are to become the main trees.

PROFESSOR CONSTANT: The work in Minnesota is real enough and well enough started at the present time to justify an explanation of what is being done there. The University of Minnesota has entered upon a real and absolute five-year course, a course that supplants everything else. It will be the only course in the Engineering College. The incoming freshmen of last year, therefore, all registered for the five-year course. The present sophomores, juniors and seniors, will be permitted to finish in the old course. The enrollment in last year's freshman class was nearly as large as that of any of the preceding classes. It has been suggested that the enrollment will in a very short time be larger than ever before, mainly because of the general and humanitarian nature of the

new course. This will attract students who might not be willing to enter the old, more narrow, technical course. If this is the case we may possibly draw students from the academic college.

In establishing this five-year course, two desirable ends were accomplished. First, the curriculum of the old four-year course was overcrowded. The expansion into five years resulted in a decrease in the number of hours per week required of all students. Second, the proposed expansion allowed an increased number of humanitarian subjects.

The basic principle upon which this five-year course was established, was this: That as much of the technical work should be placed in the fifth year, as possible. A few members of the faculty felt that the first four years should comprise a rounded engineering course, so that if students were unable to come back for the fifth year they would still have an engineering training. These members were much in the minority. Practically the whole faculty feels now that the principle adopted was the correct one. It may be thought at first that the men who cannot come back for the fifth year will lose. We feel, however, that if a man is compelled to step out at the end of his fourth year, he will be better educated, better prepared for his life work as an engineer, than he would have been had he taken the old four-year course and completed it. He will not have as many technical subjects, but he will have followed a line of study tending to broaden his mind and his view of life. Further, he will have more leisure during these four years to pursue his work thoroughly, because of the fewer hours per week under this new arrangement. He will have all of the mathematics, all of the subjects directly related to mechanics, such as hydraulics, stresses and machine design. In electricity he will have a fairly good general knowledge of the basic principles. Upon the whole, he will have a reasonable amount of the fundamental technical training that an engineer needs.

These men may wish to return to complete the course after two or three years' practical experience. They may thus

supplement their practical knowledge by the theoretical and technical work which are collaborated in the fifth year. The degree given to those students who cannot complete the fifth year will be bachelor of science in engineering. They will thus have something to show for their four years' work.

In conclusion I wish to state my firm conviction that in order to make the five-year course a success, it is necessary that we put the technical work in the last year.

DEAN RAYMOND: After listening to the account of the new Minnesota course, I would state that we in Iowa University have been doing the same thing in the courses I previously described. We consider this plan a preliminary or trial step, but we have nevertheless adopted it as one of our regular courses. Our broadening work all comes in the first four years, preparing for the technical work of the fifth year. All the higher technical work comes in this fifth year. We also give a degree of B.S. at the end of four years.

PROFESSOR HIBBARD: I would like to ask Professor Constant if every freshman who entered last year expects to remain there for the full five years?

PROFESSOR CONSTANT: This is a psychological question which it would be impossible to answer at this time. As far as we know, the freshmen who have entered fully intend to remain. How many will drop out it is impossible to foretell. I presume that many will be content with the four-year course.

PROFESSOR HIBBARD: At the University of Missouri a five-year course will go into effect in the fall of 1911. There will be no degree unless the students remain for five years. I do not see that any advance has been made if a degree is given at the end of four years; many of the fellows will be content to take that minor degree. There are many institutions that have five and six-year courses. While there are men who will stay for these courses, there are many that cannot and will not do so. What interests us at Missouri is to know if those men who entered as freshmen last fall will remain and get the degree at the end of five years.

PROFESSOR CONSTANT: To cap the five-year course, we are making the fifth year so good, so attractive, that the students will be strongly tempted to take if possible, the fifth year. If the four-year course is made too attractive, they will not come back. We realize that it is the ambition of young men to get out into their life work as early as possible. In the interest of the success of this course, therefore, we have determined to make the fifth year just as attractive as it can be. Some, of course, will necessarily drop out at the end of the four years, but we think that they will be nearly as well prepared to enter the technical vocation and better able to maintain themselves there after they have once made a fair connection with practical work and have acquired some of the initial details which so quickly flood in upon the young engineer during the first years in shop, field and office, as those from the old four years' course. In general education, in largeness of view upon life and life's problems and in ability to take their place among men they will be better off. The fifth year is just so much gained.

PROFESSOR FRENCH: There is still something to be said in regard to the length of courses. Of the large number of men attracted to engineering courses, there are many of them not fitted by birth and attainments to become engineers in the highest sense of the word. Many of these men can fill the ranks and do the routine work. These men ought to have an opportunity to have our training; but it is difficult for them to get it with the strenuous schedule of the ordinary technical school. It might, therefore, be well at the end of three years, in which there is very little engineering work, to give these men a degree. We have precedents in our leading institutions, where the men who work hard may obtain a bachelor's degree in three years. After three years' work it should be easy for those trained in the subject to ascertain whether a student has reached the limit of his capacity. If he has been faithful to his work, why should you not graduate him and let him work in the ranks where he must work anyway, and where he will fill his position acceptably. For instance, in civil engineering,

he will not have taken up many engineering studies. He might make a good instrument man and a good draftsman. A man who enters a technical school may be out of place. At the end of three years he certainly knows it. There is nothing for him to do, under the old order of things, except to drop out of the institution, with more or less stigma of failure, or else to persevere and "lumber up" the course with the sort of men that are not fitted for it. If these men obtain the degree of bachelor of science they would have obtained a training which would answer the requirements of many of them. They would leave the classes open to those who were fitted for the advanced work of the last two years, whereas the other men who had spent the three years and had learned their limitations would have as much education as they were able to absorb.

PROFESSOR NEWKIRK: I want to add a word to Professor Constant's reply to the question that was put to him. I have been in very intimate contact with the students in the university, and I think that our students regard the new course as a five-year course, and that they expect to stay the five years to get the degree. They consider it as a hardship, possibly, and would prefer to have a four-year course, but, having been entered in the five-year course, they expect to stay the five years in order to get the degree.

PROFESSOR WALDO: The real value of the five-year courses cannot be determined until five years have elapsed, and we know what percentage of the original entrants remain. Then we must investigate the greater efficiency, or what may be the greater efficiency, of those who have subjected themselves to the training of the five years as compared with four-year men *after* their first year out of college. At present we can merely guess as to the result.

PROFESSOR EMORY: In the South and West, the five-year course is more thoroughly established than in the East. Many institutions have five, six and seven-year courses. In these institutions many take engineering who do not expect to become consulting engineers, but are preparing themselves for

other lines. The benefits to be thus obtained are great no matter what lines the student intends to follow in after life, even in medicine or in the sciences. Many of our students have stayed five or six years to graduate, because they need a fuller knowledge of the preparatory work and training than can be acquired in the regular years of the course, and this is one of the things that led up to the fifth year as a part of the undergraduate work. Much of the weakness in elementary work may be due, perhaps, to the poor training obtained in the average high school. In certain parts of the country great progress has been made in the preparatory school during the past few years.

While the preparatory school may, in a measure, be responsible for the necessity of the fifth year, yet so much is crowded into four years that really five years are needed to absorb all the subjects in the present curriculum.

PROFESSOR WILLISTON: Much of the argument for lengthening the courses of study has been to provide the necessary time for more so-called *cultural* courses. May I appeal to our members to drop the use of this expression? All courses are *cultural* if they are properly taught. To those who still cherish this term I recommend Dr. Eliot's paper on "A New Definition of the Educated Man." If a young man wants to make engineering his life occupation, he cannot begin too early to get a broad view of his future work and obligations. His training, therefore, should be broad, but such breadth is better given by the quality of the teaching than by the character of the subject matter studied. Consequently, let us strive for more teachers who are masters both of their subjects and of the art of teaching, and who can inspire their students with high ideals; and let us cease trying to overload an already crowded curriculum with a larger number and a greater variety of subjects.

Courses of different lengths are desirable for different purposes. For some lines of work a more thorough preparation is needed than for others; and some young men can wisely afford to spend a longer period in getting their professional

training than others. The real question, therefore, is how many individuals and which individuals ought to have four-year courses; and how many ought to have longer courses? The number for whom longer courses are desirable is unquestionably increasing. Yet, on the other hand, if a considerable number of the engineering schools of this country should say to all the young men entering them, "It is necessary for you to spend more years, or even one year more than your predecessors have done, or get but a fragmentary training," it would I believe be a national calamity.

PROFESSOR HOLDEN: In the Thayer School, since 1893, a minor degree is given at the end of the fourth year in college (first year in Thayer School). Our experience shows that from one half to two thirds of our men return for the fifth year. For the first three years the work is carried entirely in the academic course, the student taking during that time such preparatory work as mathematics, graphics, physics, chemistry, astronomy, English and German. At the end of three years those students who maintain a sufficiently high rank in college may elect to take their work in the Thayer School. During the fourth year, the entire time of which is devoted to Thayer School work, no courses being carried in the college they take surveying, railroad construction, mechanics, mechanics of materials, materials of construction, highway construction, masonry construction, graphic statics, road design and electricity (direct current). At the end of the fourth year they receive the degree of B.S. from Dartmouth College. The men who return for the fifth year then complete their work including among other subjects framed structures, hydraulics, water supply engineering, sanitary engineering, railroad operation and administration, river and harbor improvements and electricity (alternating current). The degree of C.E. is conferred at the end of this year.

PROFESSOR FLETCHER: Our students come back to cover those matters which they were obliged to omit through lack of time. They come back because they want these courses in hydraulics, in framed structures, and in others of what we

term higher branches of engineering. We try to make our courses so attractive that after the graduates have been out for one or two years they feel the need of this extra training. These years of practical work make them realize the value of what we can give them.

MR. KENT: It would be well if everyone studying this subject would formulate for himself a definition of "culture." We have heard the expression "humanitarian studies," "humanistic studies" and "broadening studies," mentioned in the discussion of the objects of the five-year course. One man says that we need to give the student a broadening education. What does he mean by this? One hundred years ago a broadening education was supposed to be one which would enable a man, after studying Latin for eight years, to compose a poem or make a discourse in the style of Cicero. The idea was that Latin must be studied in a certain particular way. Further, it was necessary to know all there was to know on the subject of certain Greek terminations. At another time the broad man was supposed to know all about the history of metaphysics and the philosophical systems of Aristotle, Kant, Spencer, and others. Culture studies were the studies that had no immediate influence on the life of the man, but they were supposed to educate his brain and thus to make him mentally different from the ordinary man.

We have passed beyond that notion of culture to-day, but as President Schurman said, there is no satisfactory definition of culture. I have tried to form a working definition for myself, and have concluded that culture, for the present generation at least, is that kind of mental training which will put a man in touch with the thought of the time and place in which he is. That is, something that will keep a man in touch with his surroundings. For example, an American boy should be put in touch with the best of all there is at the present time in the United States. That covers some education in modern literature in natural and physical science, in politics, in political economy, in sociology, in morals, in the conservation of the natural resources, in criminology, in the government of cities,

in sanitation, in bacteriology, in art, in landscape gardening, in painting, in sculpture, in flowers, in short, in everything that tends to broaden and beautify a man's life. He should receive that kind of broadening culture that relates to his life and does not relate to his profession or pursuit. That is the culture which will keep him in touch with the thoughts of the present day, so that he can read and understand equally well the *Review of Reviews*, *The Atlantic Monthly*, *The Literary Digest*, *Science* or almost any paper on any subject. That is my idea of a broad culture.

The study of Latin and Greek, or even of French and German, does not give that kind of culture to-day. A study of any such old subject as metaphysics does not give culture unless the student goes into it far enough to be able to read articles which take up the deeper meanings of the subject, expounding the principle of metaphysics as applied to modern psychology. In other words, the student does not need a knowledge of the ancients in order to be an educated man. He should be educated in the things that pertain to the present day. I fear that the American educational system is neglecting the great basis of real culture. In a recent report of the Commissioner of Education I found a very full discussion on German education. In every high school and preparatory school a large amount of the time is devoted to drawing. In the report of the American school drawing was scarcely mentioned. In Germany, drawing is considered an essential part of the education of every boy and girl. It is considered in this country a side issue. The Germans are therefore better cultured to-day than we are in this direction.

PRESIDENT HUMPHREYS: Broadly, I am opposed to any such innovation as five or six-year courses. Generally speaking, it is absolutely opposed to practical success of the engineer. For the same reason that you have a five-year course, you could as well have a six-year, a seven-year, or an eight-year course. That is the logical conclusion of every argument for the extension of the regular course in engineering to five years. The result would be a product incapable of doing anything

except the work of the college. The way in which engineering science is progressing to-day is marvellous. If we need another year to add to our four-year course to-day, we should certainly soon need another additional year. We can never cover the whole of engineering science in a college course, and if we could we would not necessarily produce engineers. The engineer must be made outside in contact with his fellows and the problems of life, and the quicker he gets out, with the elements of engineering science well impressed upon him, the quicker he will become an engineer and the better engineer he will be. The theory that a capable engineer can be made inside college walls, no matter how accurate the teaching or how good the equipment, is, to my mind, the height of folly.

I feel very strongly on this subject. I have had a great deal to do with graduates and with the employers of our students. At Stevens that standard which we have developed and maintained has made our students in demand among employers. The product of Stevens Institute has the reputation of being fairly practical. I have myself employed probably two hundred of them. My experience has been that even with these men, as a rule, it was necessary that they should have about three years, to get a reasonable control of the practical and commercial elements of engineering. Here they needed guidance from me as to their work in the school of experience. I do not hesitate to say that the longer a man stays in college, the more difficulty he experiences in getting outside experience. Therefore, the sooner he gets to work and begins to get his information from experience, from actual work on the outside, the more speedily will he become practical. Let it not be understood that I am opposed to a college education. No man living believes more than I in the value of technical education, but a man who has a technical education needs the other education just as much. Even in the face of the recent tremendous advances in engineering science, in choosing between a school man with no common sense and with an exaggerated idea of what he has learned in the school, and a practical man who has worked on the outside and taken ad-

vantage of every possible source of information, I will take the practical man every time.

We have arrived at a length of course of four years, and I think that after four years devoted to a thorough and careful study of the fundamental principles of engineering science, a man can go out pretty well trained in these fundamentals. He will have to specialize, to be sure, for no man can at this day and age of engineering cover the whole field. He must specialize, but he should specialize chiefly after he graduates. He has got to supplement his college training with constant study to the day of his death, if he is going to be of real value in his position.

PROFESSOR SWAIN: I am sorry to have to disagree with President Humphreys, but I certainly do. Adopting his reasoning, I might argue that if we only need a four-year course, we might also get along with three years, and if we only need a three-year course, we might get along with two years, and if we only need a two-year course we might get along with a one-year course, and if we only need a one-year course, we might get along without any course at all. It is an open question as to how long an engineering course ought to be. There is no inherent reason why four years is just the proper length. Forty years ago, when our engineering schools were started, a technically trained man was not appreciated in this country as he was abroad. Graduates had a hard time to obtain employment. Manufacturing concerns did not realize that they needed this kind of man. The appreciation of technical training has steadily increased, is greater now than ever before, and will, I believe, continue to increase. After forty years, science has extended tremendously and in order to give a man even the fundamentals of engineering, more time is required than formerly.

Moreover, we have begun to realize that the object of technical education is not primarily to train a man to be a good engineer. It is not primarily to train him to be successful in his profession, but is something broader and bigger that includes that. The object of education is to train a man to

make the most of his life, and to lead the very best and most useful life that is possible for him. In order to do that he must have much besides his mere technical training. The conviction has been growing for a long time that a four-years' course if largely technical, narrows a man's outlook. It does not open to him many of the doors which must be open to enable him to get the greatest satisfaction and enjoyment out of life, and to be of the greatest service in the world. The reason why colleges have been giving this subject much attention, arranging their courses so that a man may have an opportunity to spend more time in college, is that they believe in offering him every encouragement to enlarge his outlook. In lengthening these courses of study we must of course be careful that we do not add anything which will in any way unfit the student for practical work. There is some danger that in the academic atmosphere a man will be so largely removed from the problems that will present themselves in practical work that too long an exposure of this kind may be bad for him. We must make a man immediately useful in his business and we must get him in the habit of studying his problems from the utilitarian side. We must get him interested personally in such a way that he may be a practical and not a theoretical man. We must encourage interest in outside matters, show him how to divide his attention between books and outside work.

In Germany, if a student wishes to become an engineer, he goes through a preliminary training in a gymnasium or "real-schule" and then studies four years in the technical school. In France, he attends the École Polytechnique before taking a three-year course in the École de Ponts et Chaussées. He is required to spend his vacations in outside practice in the engineering line for which he is preparing. We are coming to this practice in the United States, and it is the proper tendency I believe.

Probably the majority of students will be best suited with the course of four years but there are many men who can profit by courses longer than four years, just as there are some who

ought not to be in the technical school at all, but in the shop. The latter are only fitted to do the routine drudgery of the profession. We ought to discriminate and discourage men of only mediocre possibilities from pursuing an extended course of training. We must deal differently with different men, and encourage those who really have the greatest natural ability to prepare themselves most thoroughly by taking longer courses.

These five-year and six-year courses are, I believe, a very necessary and important development in our technical education.

DEAN RAYMOND: I heartily endorse Professor Swain's position. I want to point out a fallacy suggested by President Humphreys. It is not a choice between a man of common sense but no education and an educated man of no common sense. The selection is from among the following: (*a*) A man of no common sense and no education, (*b*) a man of common sense and no education, (*c*) a man of no common sense who has education, and (*d*) a man of common sense who has education. There can be no question at all as to which any one would select; it would be the second or the last—and the last shall be first.

MR. KENT: I am in an unbiased position regarding the lengthening of the course of study because I have a son to educate. An older boy of mine went through Stevens in four years, having had a machine-shop experience before he went there. I am quite satisfied with the result of his four-year course. Now the problem comes up as to the second boy, whether to have him take the five-year course in school, or the four-year course in school with the one or two years' course in the school of "hard knocks." I have not heard here anything which changes my opinion. I therefore still favor the short course.

PRESIDENT HUMPHREYS: This discussion seems to be quite abstract to me. Some of the statements made need comment. On any subject brought up even before a body of engineers, there would be as many interpretations of what was said as

there were members of the profession present. However, I do not understand how I can be put in the position of not believing in college education. If any man believes in breadth of education in connection with engineering science, I do. I do not want any man in my employ unless he has breadth. At Stevens our course is so designed as to give that very breadth of understanding and appreciation. It is planned to give the undergraduates that much-needed appreciation of that which can be obtained from the outside as well as that from inside the college. I distinctly believe that the effect of keeping a man in college too long is to narrow him. I think I can safely say that many of the members of our faculty are stronger in their positions and in other ways than are the members of the faculties in some other colleges. This is because they are in touch with outside life, with practical work. They are broadened by coming in contact with their fellows and meeting and overcoming the actual problems of life.

Because I say that four years is long enough it does not by any means follow that three years or two years or one year would do the work. We have tried the four-year course for many years and find that it gives a good foundation upon which later to build the superstructure. As to culture, a man who has finished four years in high school, and after that completes a four-year college course, should at least have some of the elemental features of culture. If he has made the most of his time and has any degree of efficiency in his work, he ought to be able to occupy a position requiring some culture, and he should gain in culture from day to day. The idea that we must artificially create culture seems to me a ridiculous proposition. All educational processes should be cultural if properly offered and properly preserved.

MR. PRATT: I would like to ask President Humphreys how one is to know when an engineer is competent. For example, let a man work as an engineer in an automobile establishment until he is able to run an automobile business. He makes that a specialty. Then, if he should lose his job there and go into some other branch of engineering, hydraulic engineering for

instance, he would not be considered capable. As far as hydraulics is concerned he would not be considered an engineer, as his training had been in an altogether different direction. That is, a man who is an engineer in the automobile industry is not an engineer in the hydraulic industry. The great question is, when shall we call a man an engineer; what qualifications must he have that he may properly be so-called?

PRESIDENT HUMPHREYS: It is not important what we call ourselves, or what the world calls us. It is what you can do or what I can do, it is not what we are called, but what we are, that counts.

PROFESSOR ALLEN: Allow me to record my opinion that as the greater part of the engineering work is done by young men, it is a mistake for them to maintain a student attitude for a longer period than four years. I believe in post-graduate work for a limited number of men who have a make-up such that they can make a success of life in spite of the handicap of longer periods of study. Our four-year course has been successful; it has been successful as indicated by the fact that engineering courses in colleges generally have been growing very rapidly as compared with the academic courses. The course is a success as measured by the demand for our graduates, and by the successful work of our graduates. In my judgment, we should be very slow in disturbing a successful condition until it has been demonstrated by trial on a limited scale that the five-year course does on the whole constitute an improvement.

PROFESSOR A. E. HAYNES (by letter).—The trend of modern education is more and more towards the practical; it insists that the student shall be taught to *think* and to so apply his thinking as to add material helpfulness to the world. It demands both the "cunning hand" and the "cultured brain." And thus we are brought face to face with the problem of the proper adjustment between the so-called culture studies and the so-called practical studies. This problem concerns not the college of engineering alone; it is vitally insistent in our whole system of education. It includes both the kindergarten and the university.

The marvelous development of science and of the scientific method within a comparatively short period, are largely responsible for the problem which now confronts the educational world. One of the most interesting results of this development is the elective system which is a distinct advance in education. The effect on our engineering courses has been to largely deprive them of the so-called culture studies. To bring about a proper adjustment between such studies and those of science, in the professional schools, there have been proposed thus far, two solutions; (1) to insist upon one or more years of academic training before the professional course, and (2) to lengthen the course, so that it may include more culture subjects.

In the University of Minnesota both of these solutions are being tried. Both alike insist upon a previous preparatory high school course of four years. In the College of Medicine and Surgery, two years of college academic work must precede the four-years medical course proper, and so the medical course becomes really a six-year course. In the College of Engineering the course has been lengthened to five years, the degree of B.S. being given at the end of four years and that of engineer, upon the successful completion of the full five-year course.

Two principal reasons have been given for this lengthening of the course: (1) The lack of time to make the present course as thorough as is desirable, and (2) the lack of culture studies in this course. It is hoped, in this extra year, to overcome both of these defects. The course has been so arranged as to make the last year almost wholly technical and the earlier years much less so. Thus the student may, in the first four years, get a fairly representative scientific course, but in order to secure the engineering degree, he must add this year of technical work.

The desire to find a quick road to becoming an artisan, and a wage earner, through learning some of the elements of engineering, has brought to the engineering colleges many who are not, by nature, fitted to become engineers. The new course

will encourage such men to stop at the proper point, while it will encourage the student who has in him the making of an engineer to keep on until he has given sufficient evidence of his right to be so designated.

The proof of the wisdom of this action remains to be seen, and will be awaited with much interest. If it is entirely successful, it will be an interesting illustration of the meeting of the double demand for intelligent artisans and skilled artists by a single course. In the opinion of the writer, it cannot fail in helping to meet the demand for a higher grade of engineers.

EMPLOYERS' REQUIREMENTS OF TECHNICAL GRADUATES.

BY HUGO DIEMER,

Professor of Industrial Engineering, Pennsylvania State College.

What qualifications do employers most desire in graduates from a course in mechanical engineering? In order to answer this question a circular letter, enclosing a blank form for reply, was sent to 720 manufacturers of machinery, etc., in the state of Pennsylvania and to 30 manufacturers outside of the state. As far as could be ascertained only such companies were included as operated plants of sufficient magnitude to warrant the employment of technical help, viz., those having a financial rating of over \$100,000 and employing over 100 men. The reason for confining this list almost exclusively to Pennsylvania was because the data were collected for the Pennsylvania State College. The thirty concerns outside the state were well-known employers of technical graduates, most of whom had previously employed graduates from the mechanical engineering course of the college. 283 responses were received, including 161 from firms which had not employed technical graduates and did not expect to. Among the latter were several builders of well-known steam engines and other high-grade machinery. 95 of the 283 had employed technical graduates, but had no openings in June, 1908, owing to the industrial depression, but hoped to have openings later on. Out of the 283, 27 had employed technical graduates and expected to have openings for graduates.

The first question asked was: "What personal qualifications as to character and temperament should an applicant possess, aside from technical preparation?"

The answers to this question with numbers of firms agreeing were: Good habits, clean manhood, temperance and sobriety (25); Steadiness and application (20); Obedience to

superiors, disposition to submit to discipline, and receive directions in an agreeable manner (17); ability to know men and to get along with them (12); industry (12); integrity (11); patience and perseverance (11); energy and forcefulness (7); self-reliance (6); speed, hustle (6); common sense (6); ambition, desire to advance through work (6); interest in work (5); even temper and self-control (5); address and appearance (5); good health and good constitution (5); cheerfulness (4); initiative (4); tact and diplomacy (4); thoroughness (4); loyalty (3); adaptability (3); discrimination (2); executive ability (2); stability (2); versatility, confidence, coolness, neatness, nerve, promptness (one each).

The above tabulation does not pretend to be a statement of the order of importance of the qualifications mentioned, but it is a gauge of what qualifications are most desired by the majority of employers. No doubt each of the manufacturers who demanded good habits and clean manhood would say "Of course, we must also have promptness." But it is significant that the largest number demand, as the prime requisite, good habits and clean manhood; the next largest number demand steadiness and application; and the third largest number demand obedience to superiors, disposition to submit to discipline and to receive directions in an agreeable manner.

The second question asked was: "What technical studies would best equip a candidate to fit your needs?"

The answers to this question do not indicate quite as much unanimity as might be expected, and range as follows:

General mechanical engineering (29); electrical engineering (16); chemistry, especially chemistry of iron (13); mathematics (10); applied mechanics (10); machine design (9); machine shop practice (7); structural design (7); foundry practice (6); fundamentals, foundation principles (6); drawing (6); patternmaking (5); steam engineering (5); metallurgy (4); gas engine (4); hydraulics (3); quantity production and rapid manufacturing processes (2); air compressors (2); boiler practice (2); forging (2); kinematics, hot blast heating, gas analysis, producer gas, strength of materials, thermodynamics (one each).

The answers indicate that the general line of studies in mechanical and electrical engineering represent the technical instruction that is desired by most employers. It is noticeable that so many lay stress on applied mechanics and chemistry, especially chemistry of iron. The fact that several replies included structural design—a subject not generally included in mechanical engineering courses—is also significant.

The third question asked was: "What general non-technical studies would best equip a candidate for your needs?"

A summary of the answers to this question follows: Business practice and methods, system, cost-keeping and accounting (23); English (18); shop management and economics (6); salesmanship (5); German (4); Penmanship (4); "academic" (3); "any that broaden and refine" (2); French (2); commercial law, sociology, history, "to read the language that machinery talks" (one each).

The fact that such a great preponderance of answers to this question cover business practice and methods, system and cost-keeping ought to be conclusive evidence that such work should be included in a mechanical engineering course as a major study, and not as a topic to be listed as a one-hour-per-week lecture subject to be lightly browsed over during the last semester of the senior year. It is also self-evident that English must be taught until the employer is satisfied with the English of the technical graduate. The fourth question asked was: "Have you been an employer of technical graduates heretofore? If so, have you found them satisfactory?" This question was answered by 98 of the 122 who had employed technical graduates, a summary of the answers being as follows: Very satisfactory (3); satisfactory or generally satisfactory (51); fairly satisfactory (5); "about 70 per cent. have qualified" (1); "in some cases" (7); "in a way" (1); "about the same as those without such preparation" (1); "only as draftsmen" (2); "not always" (5); "not satisfactory" (22).

Summary: Affirmative (60); undecided (15); negative (22).

The fifth question was: "In what particular have you found them most deficient?"

The answers to this question show even greater unanimity than those to any of the other questions, and may be summarized as follows: "Do not appreciate their lack of practical knowledge, nor the facts of the knowledge of the (to them) uneducated man. Unwilling to continue practical shop experience long enough. Unwilling to start at bottom and obey orders. Do not understand that they must begin at the bottom and that their education should make them better climbers instead of putting them at the top right away." (45). "Exaggerated idea of the immediate value of their services. Too impatient to get ahead. Want to be managers before they have learned the details" (14). Lack of understanding of bearing of technical data to everyday work (6); lack of resourcefulness and of applying elementary principles in solving problems (6); lack of application (4); lack of knowledge of value of time (3); lack of common sense (3); lack of knowledge of rudiments of business practice (3); lack of knowledge of good English (3); inaccuracy in numerical work (2); lack of system (1); too anxious to get into testing department (1); characterized by a crazy desire to get into designing department (1).

A particularly noticeable feature of the returns from those manufacturers who answered the form letter, was the fact that so large a proportion accompanied the return form by a cordial letter indicating their approval of the investigation and their willingness to coöperate. A few of the remarks in this connection are quoted below:

"We think that your plan of obtaining information as to employers' requirements is an excellent one, and we wish you success."

"We wish to congratulate you for your interest in this matter, and as we have in the past been on the lookout for men who have had the instruction which your students apparently have, we will be very glad to advise you when we are again ready to take on new men."

“The writer will assure you that there is a demand for such men far in excess of the supply in our particular line of business.”

“We appreciate the good work you are doing, which we think will work both to the benefit of the graduates and to the benefit of the manufacturers of the state.”

“Your letter covers a list of questions, amongst which is one, ‘In what particular have you found them most deficient?’ This question goes largely to the root of the trouble which the students of technical colleges have to encounter, namely an appreciation of their lack of knowledge.”

“The training is too special and the boys get discouraged before they can get properly settled into place and ready to take the commanding positions which their training has partially fitted them for.”

“I want to take this opportunity to congratulate you on your system of bringing these matters to the attention of those most interested. So far as I am aware practically all of the other colleges could imitate you to advantage. In the recent discussion concerning the immediate practical value to the employer and student of a technical education, it appears to be fully recognized that there is something radically wrong with the courses as they are now conducted, but no college seems to be able or willing to make such changes as the needs of the students and employers alike demand. Should the colleges take your method of finding out what was desired I believe they would have less difficulty in reaching a decision which would be of advantage to themselves and their graduates.”

After compiling the results of the above canvass, I concluded that it might be well, before closing the investigation, to visit personally a number of manufacturers in the state of Pennsylvania, feeling that these men might give me their views of the matter more freely during a personal interview than they would in writing. Accordingly the mail inquiry was supplemented by a number of interviews with presidents

and managers of some of the leading manufacturing industries of the state.

A number of these gentlemen believed that the engineering courses, as now given did not tend to equip the student for ultimate executive or administrative work. At the same time these same gentlemen admitted that a graduate from a course in arts who expects to become interested in a manufacturing enterprise is without the technical knowledge which is absolutely essential in a training for the industries.

By comparing the course in mechanical engineering as now given in a number of representative American engineering schools, it will be seen that the amount of time devoted to any one branch and to groups of allied branches differs widely, so that if one will take the average time devoted to engineering fundamentals in these schools, and then note the minimum time devoted to these same fundamentals by certain successful institutions, it appears that without even confining one's self to the minimum times, a schedule of fundamentals in engineering could be laid out that would still leave available a considerable part of the four-years course for those branches which would train the graduate for industrial management.

When these statistics were presented to the dean of the school of engineering of the Pennsylvania State College, Professor John Price Jackson, he expressed the sentiment that the land grant colleges should be the schools whose graduates should be of benefit to the manufacturers of the states which support them. He had already given considerable thought to the subject of industrial engineering, and as a result suggested that a course be mapped out to meet the demands as above expressed. A tentative course in industrial engineering was accordingly laid out and described in the *Engineering Magazine* in June, 1908.* The freest criticisms of this tentative course were invited. These criticisms were carefully considered and the course worked over from time to time during the past year. The course as finally adopted presents less in the way of radical departures from present engineering courses

* Vol. XXXV., No. 3, pp. 349-362.

than the tentative outline. The first two years may be taken in any of the other courses in engineering. In the junior and senior years of the new course in industrial engineering the following work is included, which is not given in the course in mechanical engineering: Shop methods and processes, one hour per week (one semester); shop time study, five hours per week (one semester); corporation accounting, three hours per week (one semester); logic, three hours per week (one semester); shop time taking and cost keeping (fifty actual hours); shop economics, five hours per week (one semester); labor problems, four hours per week (one semester); railroad economics, three hours per week (one semester); factory planning, four hours per week (one semester); psychology, four hours per week (one semester).

Some of the specialized work, such as gas engines, steam turbines and advanced machine design, has been omitted to permit the scheduling of the new work. In other particulars the course is identical with the course in mechanical engineering. It includes all of the mathematics, applied mechanics, and hydraulics, that is contained in the course in mechanical engineering, and the work in engines, boilers and power plants is equivalent to that given in the course in electrical engineering.

STATISTICS OF THE GRADUATES IN ENGINEERING FROM THE UNIVERSITY OF MICHIGAN.*

BY DEAN M. E. COOLEY AND PROFESSOR J. A. MOYER,

Of the Department of Mechanical Engineering, University
of Michigan.

In the legislative act under which the University of Michigan was organized in 1837, provision was made for instruction in engineering. Engineering subjects were taught for the first time in 1853, and the first degrees in engineering were conferred in 1860. The engineering courses were offered in the Department of Literature, Science and the Arts until the close of the school year 1894-95, at which time the Department of Engineering was organized as a separate school.

The rapid growth of engineering schools during recent years has excited widespread interest. It has often been asked what will the graduates find to do if this growth continues; how successful are they; is engineering a good profession; is an engineering degree really necessary to success; and would not the four years required to obtain a degree be better expended in practical work? The answer must necessarily vary with environment and with individuals. An attempt has been made towards a general answer by presenting statistics showing the careers of graduates of some of the leading schools, those from Stevens Institute of Technology and Pratt Institute presented last year being very valuable.

The University of Michigan has for a number of years been at work on a record of its graduates which is now very complete. It is kept up to date by having each graduate correct his own record once a year. When the annual letter was sent out in the winter of 1907-08, a card was inclosed asking each graduate to give—(1) the year of his graduation, (2) his occupa-

* A comparison of this paper with that by Professor F. DeR. Furman, see Proceedings, Vol. XVI, p. 307, will be of interest. Ed.

tion, (3) his title or rank, (4) his estimated present annual income from professional or business efforts, (5) his income from other sources, and (6) his total income. Realizing that some would object to disclosing information so personal, the cards were to be unsigned and returned in separate envelopes (inclosed for the purpose), and those who had graduated prior to 1887, when the classes were small, were not to give the date of graduation.

The response was very general. At that time there were 1,378 graduates of whom 89 were deceased. Of the 1,289 living graduates, no answers to the annual letter have been received from 55. From the 1,234 who answer regularly 980 cards were received. The larger number by far of those who did not return cards were among the very recent graduates, those who had not yet got started owing to the business depression in 1907.

The information to be presented consists of two parts: *first*, the careers of the graduates, compiled mainly from the Register of Alumni, published in the general announcement of the department for the year 1907-08; and *second*, their earning capacity, compiled from the cards returned.

The careers are given in detail by years in Table I. covering the period from 1860 to 1907. For convenience 42 classifications were chosen, the totals in each classification (see last column) being as follows: architects 9, army officers 1, astronomers 4, bankers 6, chemical engineers 21, chief engineers 64, civil engineers 183, clerical positions 9, college professors 35, consulting engineers 45, contracting engineers 16, draughtsmen 127, electrical engineers 69, engineering apprentices 37, engineers (general) 22, forestry and horticulture 8, inspectors 40, inventors 1, lawyers and patent attorneys 18, managers 81, manufacturers 15, marine engineers 3, mechanical engineers 60, merchants 6, mining engineers 9, missionaries 1, patent examiners 8, physicians 2, presidents 29, sales engineers 42, secretaries 9, special government experts 1, students 11, superintendents 111, teachers 43, treasurers 22, U. S. commissioners 2, vice-presidents 19, miscellaneous 35, retired 10, deceased 89, no record available 55, total 1,378.

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FIG. 1. Number of Engineering Graduates, University of Michigan, 1860 to 1907.

The number of graduates for each year since 1860 is given in the lower line of the table, and is also shown graphically in Fig. 1.

From Table I. two other tables have been compiled, giving the percentage of graduates occupying—(1) responsible positions, (2) non-responsible positions, (3) retired and (4) no record available. Table II. gives this information for each of the years 1877, 1882, 1887, 1892, 1897, 1902 and 1907, and Table III. for the groups of graduates in the five-year periods between the years of Table II.

TABLE II. PERCENTAGE CLASSIFICATION OF LIVING GRADUATES BY SINGLE CLASSES AT 5-YEAR INTERVALS.

	1877 80 yrs. out.	1882 25 yrs. out.	1887 20 yrs. out.	1892 15 yrs. out.	1897 10 yrs. out.	1902 5 yrs. out.	1907 0 yrs. out.
Responsible positions.	100%	100%	92%	85%	63%	42%	10%
Non-responsible positions.	0	0	8	15	35	55	77
Retired.	0	0	0	0	0	0	0
No record available.	0	0	0	0	2	3	13

TABLE III. PERCENTAGE CLASSIFICATION OF LIVING GRADUATES BY 5-YEAR GROUPS.

	1878-'82 inclusive.	1883-'87 inclusive.	1888-'92 inclusive.	1893-'97 inclusive.	1898-'02 inclusive.	1903-'07 inclusive.
Responsible positions.	94%	93%	84%	65%	52%	24%
Non-responsible positions.	3	5	14	32	42	69
Retired.	0	0	0	1	1	0
No record available.	3	2	2	2	2	7

MR. KENT: How do you separate the responsible and non-responsible positions? What do you call a responsible position, and what a non-responsible position?

DEAN COOLEY: In classifying, a man was considered to occupy a "responsible position" as distinguished from a "non-responsible position" whenever his work was of a character to require him to exercise his own judgment rather than to follow the judgment of another. More specifically, army

officers, astronomers, bankers, chief engineers, consulting and contracting engineers, college professors, managers, manufacturers, presidents, vice-presidents, secretaries, treasurers, superintendents and government commissioners were put in the first class, while draughtsmen, inspectors, salesmen, teachers, clerks, engineering apprentices, and students

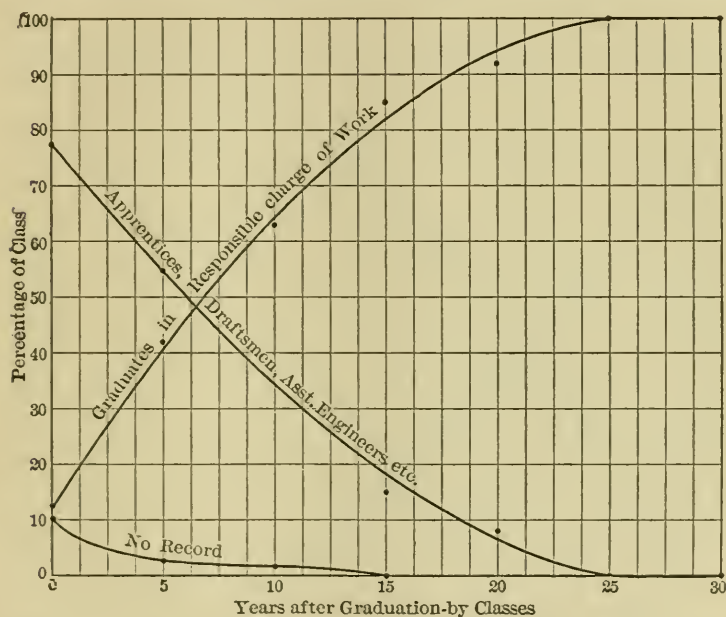


FIG. 2. Percentage of classes, at five-year intervals, in responsible and non-responsible positions.

were put in the second class. Those reporting themselves under the general heads of architects, civil, mechanical, electrical, chemical and marine engineers, were classified in accordance with the details of their records, some in the first class, the rest in the second.

It appears from Table II. that for students who have but recently graduated 10 per cent. found themselves in responsible positions inside of six months; 42 per cent. at the end

of 5 years; 63 per cent. at the end of 10 years; 85 per cent. at the end of 15 years; 92 per cent. at the end of 20 years; and 100 per cent. after 25 years. These percentages are shown graphically in Fig. 2.

Considering the five-year groups in Table III., 24 per cent. found themselves in responsible positions during the first five

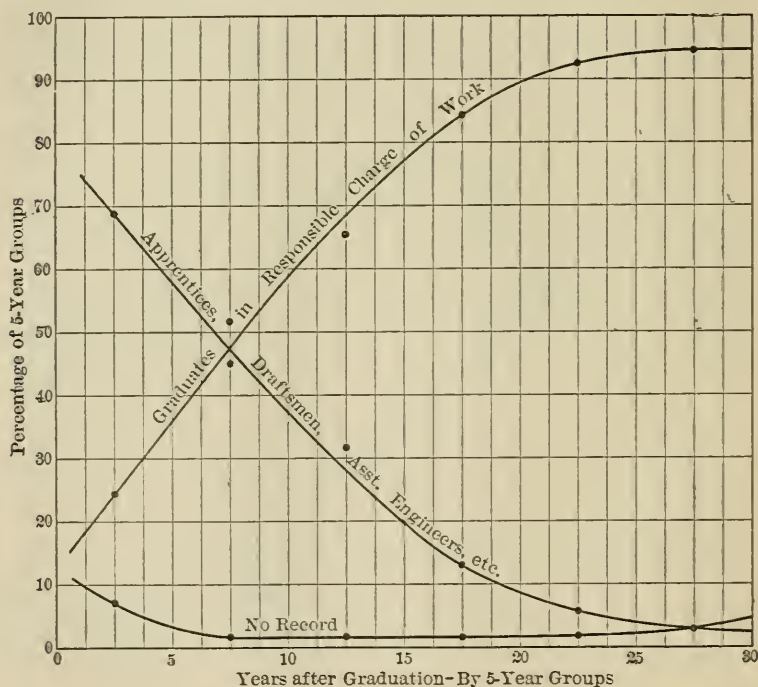


FIG. 3. Percentages of graduates in five-year groups in responsible and non-responsible positions.

years out of college; 52 per cent. during the second five years; 65 per cent. during the third five years; 84 per cent. during the fourth five years; 93 per cent. during the fifth five years; and 94 per cent. during the sixth five years. These percentages are shown graphically in Fig. 3.

The earning capacity of the graduates is given in Figs. 4, 5 and 6. In Fig. 4 the *average salary* for each class has been plotted; that is, for each class since 1887 the different salaries reported have been summed and divided by the number reporting in each class. Prior to 1887, as the year of graduation was not required to be stated on the cards, the average has been taken of all the salaries reported and this average is plotted on a straight line. It appears that for the first year, after leaving college, the average salary was a little more than



FIG. 4. Average salary for each class.

\$900. A steady and fairly uniform increase is shown each year for fifteen years at which time the salary was between \$4,300 and \$4,400. After this there was greater variation due to some unusually large salaries. If these larger salaries be eliminated, the yearly increase would be fairly uniform from \$900 the first year, up to \$6,000 the twentieth year. After twenty years the information received shows an average salary of about \$5,600.

In Fig. 5 the *average total income* has been plotted. The yearly increase and variations correspond in general with those shown in Fig. 4. During the first year the average was

a little less than \$1,000, which increases up to between \$4,700 and \$4,800 at the end of fifteen years; and, eliminating the unusually large incomes for one year, the yearly increase would be fairly uniform up to \$7,500 or \$8,000 the twentieth year, with an average of \$7,300 after twenty years.



FIG. 5. Average total income for each class.

In Fig. 6, the variations in *salary* for each class have been plotted: that is, the maximum and the minimum salaries are shown at the extremities of the heavy vertical lines, the average salary is shown by the points between them. These intermediate points are connected by the broken line of Fig. 4.

Approximately, the salary varied the first year from \$0 to \$2,000, mean \$900; the second year, from \$500 to \$4,500, mean \$1,300; the third year, from \$0 to \$2,400, mean \$1,300; the fourth year, from \$900 to \$5,500, mean \$1,700; the fifth

year, from \$1,200 to \$4,000, mean \$1,900; the sixth year, from \$1,200 to \$7,500, mean \$2,500; the seventh year, from \$1,000 to \$6,000, mean \$2,100; the eighth year, from \$1,200 to \$8,000, mean \$2,600; the ninth year, from \$1,000 to \$6,000, mean \$3,100; the tenth year from \$1,100 to \$9,000, mean \$2,500; the eleventh year, from \$1,200 to \$7,100, mean \$2,700; the twelfth year, from \$500 to \$10,000, mean \$3,100; the thirteenth year, from \$2,000 to \$6,000, mean \$3,100; the fourteenth

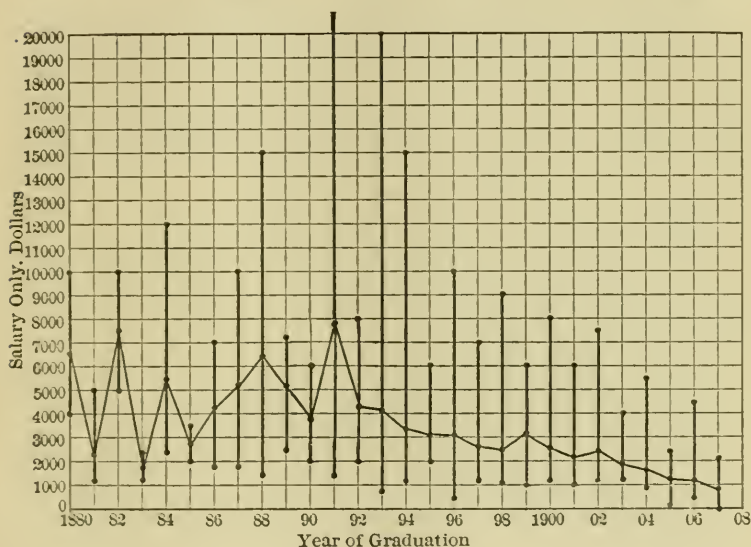


FIG. 6. Maximum, minimum and mean salaries for each class.

year, from \$1,200 to \$15,000, mean \$3,400; the fifteenth year from \$800 to \$20,000, mean \$4,100; the sixteenth year, from \$2,000 to \$8,000, mean \$4,300; the seventeenth year, from \$1,500 to \$70,000, mean \$7,700; the eighteenth year from \$2,000 to \$6,000, mean \$3,800; the nineteenth year, from \$2,500 to \$7,200, mean \$5,100; the twentieth year, from \$1,400 to \$15,000, mean \$6,400. After twenty years the maximum salary varied from \$2,400 to \$12,000, the average maximum being \$7,600; and the minimum salary varied from \$1,200 to

\$5,000, the average minimum being \$2,400. The average salary after twenty years, as shown on Fig. 4, was \$5,600.

As the object of this paper is to present statistics and to explain how they were obtained, no attempt will be made at arguments based on them or to draw conclusions. It will be interesting, however, to see how the inquiry impressed correspondents, and for that purpose the following extracts are quoted from the replies received:

One of the older graduates wrote as follows:

"It strikes me that the results of a life-work are not measured entirely in dollars and cents: but if you want to gauge success and results by dollars and cents I am sure I do not know what value can be placed on the increased enjoyment and the profit of life due to a university education. I should say much in some cases and none in others."

A well-known civil engineer wrote the following:

"The prejudices of business men arise from too much time given to the study of dead languages. A college course is essential to a civil engineer."

From a younger graduate:

"I consider that the general education, polish, and physical aid amply repaid me for my college expenses."

From the reply sent by a well-known mining engineer the following sentence is taken:

"In the mining business college men have been doing by far the best."

A less optimistic reply:

"My college education has not as yet proved to be much of a success: but I am waiting for future developments."

A professor of physics in a western university says that in estimating the value of a college education its money value is not the only criterion.

A young engineer in a manufacturing company is more sanguine regarding the money value of an education.

"I believe a college education and an engineering degree are worth at least one thousand dollars a year. My father at my age was receiving seventy-five dollars a month and he had been with his firm for thirteen years."

The head of a firm of consulting and contracting engineers states that he is firmly convinced of the advisability of a college training and that he believes, further, that his technical education is his greatest asset.

A graduate of one of the earliest classes, now retired from business, states that he believes that the cost of a college education is justified. He adds, however, that he is unable to say what would have been the effect if four years had been well used in business.

A graduate of a class in the early seventies, who gives his occupation as a farmer and horticulturalist, states his opinion as follows:

"I would not sell my college experience and culture, at the cost of both the money and the time and the interest thereon in addition."

The following is taken from a letter sent by a graduate who is now a professor in one of our leading technical schools:

"I doubt very much if such information as you here seek will lead to the truth. It would be very hard to compare your results with the income of the same number of exactly similar men who have not been college-bred. My opinion is that in very many cases the claim of these business men is a just one."

In reply to the formal set of questions sent out to all the graduates, a farmer sent the following reply:

"Annual income—a happy family. Total income—a contented life. Abundance to live on."

A well-known graduate wrote as follows:

"The discipline received and a habit of close and sustained application which I received during my four years at Ann Arbor, have been of very great advantage to me."

An architect with a national reputation adds the following to his formal reply:

"I believe a university training is of the utmost benefit to any man who is to take a place in the great world. His success is measured by what he does and not by his income."

The following borders on the pessimistic:

"I do not consider that my present income or any earnings

of the near future to be conclusive evidence as to the value of a college education to myself. I believe, however, that the returns justify the average young man in securing a technical education."

A man who had much difficulty in earning his way through college and who receives a meager salary writes as follows:

"I feel that all I received in my college course was not due alone to my books, but I received just as much from my fellow students, professors and instructors. The value of what I learned from them can scarcely be measured in dollars and cents. The influence of some of the older professors is to me far more than commensurate with the money invested in a college education."

As showing the versatility of the college-bred man the following is taken from the reply of a recent graduate:

"When the financial scare occurred last fall, the company dismissed several of its design corps. They called two or three of us who were college men and told us that we were to be retained, because they knew they could put us anywhere in the plant when there was not much designing to be done."

The vice-president of a prominent concern wrote curtly as follows:

"In regard to the part of your letter relating to statistics, I must say that I have no use for data of this kind and shall absolutely decline to contribute."

A graduate of the engineering department who has had a great deal of experience in practical affairs wrote at length in response to the formal request for information; the following paragraphs are quoted from his letter:

"There is no question in the minds of thinking and progressive business men that a technical education, thoroughly instilled and applied with common sense, is the best equipment a man can have.

"Mr. Crane loses sight of the fact that technical training does not make mechanics nor is it intended to make mechanics, but it does train men for positions which mechanics can obtain only after years of experience and study.

“I have served my time in the shops as a regular apprentice, and I know many others who have done the same; I have found that the technical man who goes into the shops and acts like a man, takes his bumps good-naturedly and does his best, soon finds that he is able to outstrip the ordinary apprentice and can soon rise to positions which make him the envy of his fellow workmen; and they will involuntarily testify to the superiority of technical training, either gladly or grudgingly, by such exclamations as ‘Gee, I wish I knew as much as that fellow, you wouldn’t see me here running a drill press’; or ‘I’ll bet if he didn’t have a college education he wouldn’t be a gang-boss before he finished serving his time.’”

A young engineer with an uncertain income wrote as follows:

“My business is such that it is sometimes done at a fair profit and sometimes done without a profit—but suffice it to say, that I consider that I have prospered, and that my prosperity is in a large measure due to the training I have received at my alma mater.”

The foregoing replies were volunteered. The request for information was confined to the data sought. But great interest was manifested, the responses being in general like those quoted. Many gave consent to have their names and letters published if desired.

MR. KENT: About what percentage of replies to your inquiries were received?

DEAN COOLEY: That part of the paper relating to the careers of graduates was based on replies from 95.7 per cent. of the living graduates; the earning capacity of graduates was based on replies from 76 per cent. of the living graduates.

REGULATIONS GOVERNING EXAMINATIONS.

BY W. K. HATT,

Professor of Civil Engineering, Purdue University.

ATTITUDE OF PUBLIC.

Dishonesty of students, particularly in the form of cribbing at examinations, is not regarded seriously by all persons. The attitude of a part of the public is well typified by that of the *New York Sun* in its flippant and amusing comments on the recent restrictions put in force at Columbia University, in New York City, during examination periods. To the graduate, it is generally a minor evil and often associated with college pranks. It does not appear to him that any moral obliquity has resulted from the practice of his college days. The latter were, as he recalls them, mainly of association with his fellows and the absorption of the general life of the institution. The definite result of particular studies is not recognizable, although he, in many cases, feels that his character has been formed and certain standards created by the personality of a few of his professors.

Not all instructors are seriously concerned in the presence of widespread cheating.

While there is a difference of attitude towards the fault, there is also a wide difference in the methods proposed for prevention on the part of those who consider the offense serious. The extremities are: First, with that side that believes the best results come from the honor system, and that cheating is fanned to a flame by measures designed to prevent it; and second, with that side that believes the so-called "honor system" to be an invitation to dishonesty, and that the conditions surrounding the examination should be business-like and designed for prevention.

This paper, first of all, considers the extent and nature of the problem of student cheating; second, gives the arguments

for and against the so-called "honor system"; third, presents testimony of experience of other institutions and some account of our efforts at Purdue University to regulate the evil.

That children accomplish their work in the primary grades by dishonest means and the practice continues through the high-school is a well-known fact. Only a few years ago, there was found to be very active dishonesty in the entrance examinations to one of the eastern universities on the part of graduates of two smaller colleges in which training in manly virtue and moral strength is considered to be the chief contribution of these schools. In the last few weeks, newspaper reports indicated an upheaval at another eastern university. The reports of the dean of the faculty of arts of Cornell University during the past few years give evidence of the extent of the problem at that institution.

It will be of little avail to multiply instances. Universities, no doubt, prefer to wash their linen at home, and the files of our educational societies contain little discussion of successful or unsuccessful war against this plague. Thus there is little public discussion like that that accompanies fraud in athletic relations, and many trustful and optimistic persons cry peace when there is no peace. The true conditions may not be apparent.

Correspondence that the speaker has had with various institutions throughout the country to inquire concerning the prevalence of cheating and the means of prevention makes it very clear that the problem exists in most northern colleges and is not being ignored.

One difficulty of the situation is that the results of the practice are insidious. The defects produced are latent defects. A fault like intoxication is patent to all. The harm is physical. The student who habitually practices fraud may develop a weak mind without disturbing the peace of the community as does a drunken or disorderly student. And so, in a large way, the class work in a given department of instruction may be undermined without surface indication of the underlying condition. From the standpoint of the mental development

of the student, which must suppose discipline, it would seem that we cannot afford to regard the problem lightly, as a curious and an amusing perversity of student life, or as a necessary condition of instruction.

CAUSES.

If we can ascertain in some manner, the causes of this evil, we will be in a more intelligent position to apply suitable remedies.

Certainly, one of the fundamental, underlying causes is the low moral tone of the home and the community, which applies the test of success without examining the moral condition of the individual who arrives and the paths he has taken. The habits formed by the practice of dishonesty in the lower schools are an immediate cause of the problem in some institutions and standards of honesty must be created.

On the campus new influences arise. Some studies bring intellectual strength and therefore intellectual integrity; some instructors give the individual a new moral standard. On the other hand, some studies are prescribed that seem to the student to be unnecessary and useless performance. Again, he may be forced to take a course which is out of gear with the remainder of the curriculum and for which he is not prepared, or he may be forced to take severe courses which are poorly taught. All these lead him to dishonest means of acquiring credit. He may attempt also to take advantage of a too trustful instructor, whom he does not know personally and to whom he has no sense of personal loyalty. Loose methods of administering examinations also tempt him to cheat.

One other underlying temptation must be acknowledged by every instructor when he comes to consider his own practice. He must feel the inherent opposition of two men within himself; namely, the teacher and the examiner. The temptation is to neglect the latter.

Teaching itself is an art, and the teacher is like any other artist who does his best work and exercises his best influence in an atmosphere in which regulation and suspicion and mean-

ness are far distant. Unfortunately in this world he cannot leave his work at this point, but must also be an examiner and disciplinarian, and in this capacity he must conduct his affairs in what we call, for want of a better term, "a business way." The art of steering a wise course through life is not an easy one or possessed by the majority, and it would seem that the art of wisely combining the inspiration of a true teacher with the effectiveness and system of the more common type of instructor is an end difficult to attain, but to which one should aim.

The roll of educators contains the names of impressive characters that so impose themselves upon the student body that a contest like that of examination is conducted under honorable conditions. The chances are, however, in this age and community, that the contest will be like that of intercollegiate athletics, where victory is the end rather than an honorable contest between gentlemen. With sympathy and a knowledge of the good points and strength of student character, those who have longest given instruction yet measure truly student weakness. It appears that those institutions, which, in this latitude, have been longest in the business of instruction have not yet found a royal road to character.

One other difficulty that confronts us, but which did not confront, in so great a degree, the old educators is due to large classes where there is little personal contact between professor and students, although this is not true in drafting room and laboratory work. This is not true of all institutions, and not necessarily in laboratory and drawing room work. However, the statistics recently presented in *Science* by Professor Guido Marx show in all institutions an increasing proportion of instruction to be given by young and inexperienced men.

It is true that the student work of the engineer and the scientist, in general, leads to integrity of mind and sturdiness of character. Most of his tasks are self-examining. On the other hand, he has in general, too much to do, and is tempted to satisfy requirements by improper means when pushed to it.

The above considerations are some of those governing the problem.

Granting this problem, and the necessity of controlling, by some means, student cheating and of educating the individual in the early years of his course, we find two methods in use that work from directly opposite points of view; namely, the honor system and the proctor system. Men of good judgment and experience are widely at variance in their conclusions upon this matter.

METHODS OF CONTROL.

The honor system, as a system, and not an informal understanding, may be described as follows:

All examinations and written recitations are conducted on a system under which the instructors either leave the room or turn their backs upon the students. This usually follows a formal acceptance by the students of the honor system, which involves the use of a written pledge that they have neither given nor received help in the examination. If a student is detected by one of his classmates in cheating, or if a professor discovers evidence of cheating in the written paper handed in by a student, the evidence is placed in the hands of a committee, called the honor committee, whose business it is to administer the honor system. In one college, this committee consists of the presidents of the four classes and two additional upperclass members who were members of the committee of the preceding year. This committee summons the accused student and if, after investigation, it finds him guilty, it recommends to the faculty that he be finally dismissed from college.

Its advocates make the following claims: That it emphasizes honesty more and dishonesty less. That students can cheat even under the sharp eye of a suspicious instructor, and if faculties offer a bonus for results obtained by cheating many a student is tempted thereby to accommodate the faculties. In any case, there being a certain amount of cheating under any system, it will be less under the honor system and the majority of the students will escape the stigma of suspicion of dishonesty, which is forced upon them by the system of regula-

tion. A man should be assumed to be honest until he is known to be guilty, and that this assumption of honesty should obtain among gentlemen. The fewer the regulations that assume misconduct the better will be the conditions. In any case, extreme repressive measures do no good; it's the hardest blow but hits the thumb. The admitted success of the honor system in small colleges in the South and in Princeton University shows that, under certain conditions, the system is applicable, inasmuch as the university is looked upon to give the training of the honor system.

These arguments seem to be very general, but they are the actual arguments advanced by men of judgment and experience.

On the other hand, those who administer a system of regulation hold that, while it is disagreeable to treat men like thieves, such treatment is a positive protection to men who are disposed to be honest, and point out that the honor system assumes cheating in the student body equally with the regulation system. In any case, power of public opinion will not prevent dishonesty, and if dishonesty exists, the faculty rather than the students should deal with it. The student code of honor is that no student shall inform on another, and it is more dishonorable to be an informer than a cheater. One objection to the honor system is that it cannot be carried out in all cases; it is dependent upon the sentiment of the student body, which has to be stimulated and educated with each generation. This requires many lectures and full presentation before the students. This difficulty of lack of continuity of students is one of the greatest difficulties. After one class has been aroused to a sense of duty, the next class will fail to realize it, and there is a sort of constant revival. They point out that there is nothing to prevent the moral influence of instructors and the presentation of standards of morals under the system of regulation. Indeed the maintenance of a high tone in matters of this kind is one of the important duties of the teacher. A complacent teacher is apt to assume that dishonest practices do not exist in his classes, whereas the facts

may be quite the reverse. They point out as the result of experience that the honor system has often been a failure. Poor fences make unruly stock. Again, it is said to be the duty of a university to the public to have utmost knowledge that the student has met the imposed restrictions fairly. Honest men would, on the whole, prefer to be watched, in any case, rather than to be trusted. The experience of students in rejecting the honor system shows this.

They point out that the student's work in after life is to be conducted under just such supervision. Thus, the exponents of regulation consider it good business to place such restrictions on examinations that they may be sure that the standards are being met honestly.

They realize that this is not an ideal state of affairs and that some day in the distant future standards of honor and morals may have improved and our student conscience so aroused that there will be no necessity for regulation; that the regulation system is, on the whole, safest and brings best results.

The writer's belief is that progress in creating a student conscience in relation to this matter and diminishing dishonest practices on the part of those who have no conscience may be reached through concerted action and a definite policy.

He believes also that an instructor has it in his power, if not absolutely to prevent cheating, at least to diminish it to a negligible quantity. A large amount of cheating, like a large number of "conditions" or a great amount of tutoring, is a symptom not necessarily of some failing in the student body, but an indictment of the course or the conditions of teaching, or of examination. The teacher must handle the matter with judgment. By the union of good instruction, justice in dealing with students, and so winning their confidence, and by reasonable regulation of examinations, he ought not to be troubled with this problem. An instructor should not mistake himself for one of the great teachers like General Walker or Thomas Arnold, and dwell in a cheap paradise, his ordinary precaution thrown aside, confused by high words and in the false security of an unreal view of a student nature.

Student dishonesty like political impurity is raised from the status of a conventional fault only by agitation and consideration and punishment. Certainly, purity in politics is no longer to be regarded as an iridescent dream, and the writer is not willing to believe that great progress cannot be made toward a more sensitive conscience and greater integrity of our student body. The path must, in my view, be through education. As in the training of children, progress comes from expostulation, regulation and punishment, and not by allowing an assumed better nature to operate without restriction. Our task is never done, and we should not falter or turn backward or lose the present progress.

The writer had some hesitancy in presenting this paper in view of a possible charge that affairs must be serious at the institution with which he is connected. Inquiry has, however, convinced him that the same problem confronts other institutions of highest rank in the Middle West. And so these words may be of value to others.

During the year 1906 and 1908 the writer was in correspondence with some forty old institutions relative to student dishonesty and the method of handling it and the experience, if any, obtained in the application of the honor system.

The replies were interesting and threw much light upon this question. Space does not permit the quotation, even in abstract, of correspondence, and it does not seem advisable to quote portions of the correspondence. It is hoped that this paper will bring forth from these correspondents views expressed in letters to the writer.

REGULATIONS.

In the institution with which the writer is connected a committee was appointed four years ago to study this problem, and to handle all cases of suspected dishonesty, and if possible to formulate rules of procedure. Experience obtained has led to the following rules which are drawn up for the guidance of members of the faculty:

It is assumed that the best interests of the class are best served by removing opportunities for obtaining help; that students and instructors will prefer such conditions as will necessitate only a general supervision of the class on the part of the instructor.

No question shall be written on the blackboard after the students begin the test.

The instructor shall not leave the room during the progress of the test.

The instructor shall not perform any duties during the progress of the test that divert his attention from the students. Sitting at the desk in the front of the room and reading or correcting papers, etc., constitute defective supervision.

No two men in adjacent seats shall be assigned the same questions, or questions which demand similar drawings.

Large sections shall be provided with a sufficient number of monitors.

Whenever problems and reports are given for work outside of class, assignment, correction, and administration should be such that individual work on the part of the student will be insured as far as possible.

Exercises, drawings, compositions and reports should be punched or otherwise defaced to prevent their subsequent submission by other students.

That all cases handled by the instructors, apart from the committee, should be reported to the committee for record.

That the instructors to whom the freshmen report, lay before their classes ethical standards in respect to the use of the work of other students in themes, essays, and lecture notes, and with reference to the use of quotation marks.

That no credit be recorded in class book for work submitted, such as problems, in cases where the instructor is not able to assure himself that the work submitted is the individual product of the student.

A student found guilty of dishonesty by the faculty shall not participate in any public exercises of any student or university organization.

One of the most effective rules is the last.

Such rules as these require the sympathy and coöperation of the entire instructional corps. It takes some time however to bring this about, but as the faculty is more or less fixed in its personnel, the task is not so difficult as continuing the proper spirit in the ever-changing student body.

DISCUSSION.

PROFESSOR ALLEN: The rules formulated in the paper are somewhat more elaborate than the rules of the institution with

which I am connected. One of our rules of conduct is that the presentation by a student of the work of another as his own will render the student liable to dismissal. This is our only rule. We have but one serious penalty and that is dismissal. We have no penalty of suspension, and in cases of dishonesty, dismissal is substantially certain. The student has an opportunity to present his case, not before the entire faculty, but before a committee of three, generally appointed for the purpose of giving him a hearing. The professor who brings the charge is naturally not a member of the committee.

As far as my own examinations are concerned, I do not believe in the honor system, and I am free to say that I approach the examinations without any anticipation that there will be any dishonesty. As that is in fact my attitude, I believe that the students know it and appreciate it. Some of the professors in the department have been told by graduates that students did not cheat in my work and I thoroughly believe that that is the case.

PROFESSOR WALKER: I want to add a word to what Professor Allen has just said in relation to the student bodies. Twenty years ago, when I was a member of the student body of the Institute of Technology, I think that any student that was guilty of dishonesty in Professor Allen's room or in that of any other member of the civil engineering department would have had a hard road to travel with the class. I was in examinations where the instructor was out of the room by necessity for ten or fifteen minutes and never saw any of the students do any crooked work under those conditions. I do not believe that my class was composed of any better clay than those of other institutions, where I am sorry to say that I have seen other conditions prevail.

I have given this matter a good deal of thought, especially for the past five or six years, and I must say I am about as far from a conclusion as I was when I started. Returning to my own college days, I recall one instance where a member of the class was guilty of passing in drawings of another man as his own. This was detected by the professor and that student's

connection with the institution was severed inside of twenty-four hours.

As a teacher in two institutions in the last fifteen years I have had some experience with honor systems. In one institution the honor system was adopted by a certain class and it worked for a couple of years. It was a class matter and not a college matter, and for some reason, possibly the ridicule of other portions of the college, the system was dropped before the class graduated. The institution with which I am at present connected has the honor system in vogue for certain sections of certain classes and not in other sections of the same classes. The faculty has permitted those parts of the student body in which there were large majorities in favor of the system to use it in their examinations and in their class work and it has worked well not only in written work but in daily blackboard work. I have had students from these sections in some of my classes taking work in the same subject as students from other sections in which the honor system was not in vogue.

In some of the sections of the college, where there is not the honor system under that label, the spirit of the honor system is just as strong in practice as in those in which the label is applied. In my examinations and recitations, I treat my students as men of honor and state to them that I do not intend to act as a policeman, but that if I notice anything irregular in the room or on the papers passed in, the guilty party will get just as severe treatment from me as from any of my colleagues. I believe the men have met me more than half way and I am glad to record my experience with college students, that if treated as men of honor they will respond. On the whole, I favor the honor system when adopted by a large majority of the students concerned.

DEAN RAYMOND: One point mentioned by Professor Hatt was the fact that sometimes examinations are held by instructors not actually known to, or acquainted with, their students. That opens up the question of large classes as compared with small classes. Perhaps some element of dishonesty gets into

the atmosphere in our schools when we advertise and receive a larger number than we can honestly teach. Further, we should not employ young instructors to teach by themselves. My own way of using a young instructor (when it is possible), is to have him assist me. I lecture or quiz and then turn the class over to the young instructor to assist in the working of problems that depend on the work of the quiz or lecture. I do not believe in the honor system, or any other system. I believe in conducting examinations so that the student can not cheat and so that there shall be no reason why he should cheat. It requires a great deal of study to arrange examinations in all subjects so that this is possible, but I believe it can be done by careful study.

I do think, however, that there has been a change in the sentiment regarding examinations in recent years. There has been a tendency towards dishonesty, whether the class is large or small. It may be due to the prevailing atmosphere of our public life. I have borrowed from the *Engineering News* a sentiment and am putting it on the glass door in the vestibule of our engineering building; it is this: "The best asset the engineering profession has is its reputation for honesty, and it is the duty of every engineer to preserve that reputation unsullied." I thoroughly believe that every examination can be conducted in such a way that there will be no inducement for a student to cheat, and if this can be done the whole notion of dishonesty in examinations can be done away with.

PRESIDENT HUMPHREYS: The first day of my presidency at Stevens Institute I expressed to the students the hope that the day would come when the honor system could be introduced, but that the faculty could not introduce it—it would have to originate with the students. After a number of years the result of this expression of that hope repeated from year to year is that we have had the honor system for about three years. I do not pretend to say that it works perfectly. During nearly sixty years of life I have not found anything perfect, nor do I believe that anything will work perfectly in this world. The system was finally adopted by the faculty, but it

had to begin with the students. A certain class came forward and asked permission to try the honor system in their senior year. I listened to their argument as to why it would work, etc. Later the plan was discussed with the faculty and finally adopted for this class, and has developed further from that beginning. After these classes had passed their examinations and graduated, we called certain representative men before us and consulted them as to its working. We have done this with each succeeding class. Some express themselves as doubtful, some as hopeful, and some that it is undoubtedly a success. To those who expressed doubt I would finally put this question: Is there more cheating to-day in Stevens Institute than there was before? Invariably the reply has been that there is not as much, and that it is a success from that standpoint. I find that honesty in examinations is secured by meeting the boys half way, by going into the matter with them in a spirit of fairness. I have known of cases in Stevens Institute where boys had to be expelled for cheating in examinations where I would have preferred to expel the professors rather than the students. In school, as in life, if you trust a man he will play fair as a rule.

The honor system is working to the advantage of the institute and to that of the students. It has also developed a student self-governing board which coöperates with the committee on discipline and scholarship. This committee of students is consulted upon any new question. What the faculty finally does rests with itself, but the students are consulted and their advice is taken as far as possible. It was two years ago that this plan was adopted. I was fearful of carrying it out to the extreme to which it finally developed. To illustrate how the boys stuck to their duty, there were four very prominent men who were tried by the self-governing board. They were particular friends of men on the board. These men were active in outside affairs and one promised to be the greatest athlete the institute had ever had. The men were tried and found guilty and all left the institute. Last year there was only one case and the faculty knew nothing about it until the

student board reported. The board brought the man's name up and he was tried and recommended for expulsion. He was expelled.

In conclusion I wish to say that the system is not perfect. It is better than previous plans in that the spirit of coöperation which it has developed is of great value. That there is a better moral tone in the institute by reason of our honor system, I am firmly convinced.

PROFESSOR HIBBARD: I can express my thought on the subject of examinations in three sentences: (1) Ask questions that cannot be prepared on the "roller crib" or scroll, (2) make the examination a real piece of education, (3) make it a fair examination.

MR. SHOUDY: I can speak from the experience of a younger instructor with reference to the Stevens Institute honor system. I know many of the boys intimately. Some of them I know and value as chums. They call me by my first name and I call them by theirs. I go out with the boys and they seem to forget the fact that I am their instructor. I went to Stevens as instructor six years ago, when there was no honor system. I have taken great interest in noticing the attitude of the students towards the system and towards the professors. They now believe that the professors are treating them fairly and they therefore conclude that they cannot do otherwise than to treat the professors similarly. There is in the majority of students a latent sense of honor.

There is a certain class of work which I teach in which it is extremely difficult to detect dishonesty. In the past as now, we have assigned problems to be done at home. Before the honor system was used, the boys were not doing this work. I have heard that out of eighty in a class, ten men did the problem and the rest got their solution from them. Early this year I told the boys that I wished them to do their own work and that if I found they were not doing it, the severest penalty would be placed upon them. I know positively that almost without an exception those problems were worked individually in complete detail.

When I say that the honor system is a success I have two reasons for it—(1) a careful examination of the papers discloses no evidence of cheating; (2) my conversation with the boys brings out evidence of the same fact. Another evidence is the elevation of the moral tone of the college in the past two years. Not only is the scholastic work improved, but the theoretical work is better. The men are more willing to work and to devote their time to doing the work themselves.

The honor committee was of course an innovation. The situation this year was difficult to cope with. During the first part of the year some members of my class were rather disorderly and as I am not much of a disciplinarian, the honor committee took upon themselves to discipline the unruly members.

DEAN COOLEY: Perhaps a few words regarding another method of conducting examinations will be interesting. For the past two years I have framed questions so as to draw from the students answers which show me their understanding of the subject without requiring answers to definite questions. For example, in the course in public utilities, the students were asked first to discuss the possibility of a three-cent fare. The second part of the question called for the elements of the problem and an estimate of their relative weights in reaching a conclusion as to the possibility of the three-cent fare. I do not care whether they put into their answer what I had gone over with them or not. As a matter of fact there were some of the students who said that I was wrong in my argument; and that another professor who argued on the same subject was wrong also. They then stated that their own opinions were so and so. That lot of papers was the most interesting I have ever read. Every one was a surprise to me from the beginning to the end. I believe that with a little ingenuity questions could be so framed as not to raise in the minds of the students any suggestion of cheating. The answers would come in such a way that it would be practically impossible for students to copy from one another.

PROFESSOR THOMAS: In the upper classes, cheating is even

more serious than in the lower classes. An examination every two weeks or once a month is good because the student feels that there will be many of these tests and failure in one is not necessarily serious. Further, the memory is fresh in the subjects so that the student does not have to cram for the examination. The more general adoption of computation periods, in which the students receive all the help that can be given by instructors, would tend to reduce dishonesty.

REQUISITE QUALIFICATIONS OF AN ENGINEERING COLLEGE INSTRUCTOR.

BY OLIVER B. ZIMMERMAN,

Charles City, Iowa.

As one reads the papers presented for consideration before our Society, as given in the "Proceedings," it would be evident that those most often treated are the engineering courses, equipments, laboratories, buildings and methods of presenting the engineering subjects, while an important factor of the engineering college—the instructor—his qualifications and his improvement has so seldom been discussed or even hinted at, as to make it remarkable in a society whose specific purpose for fifteen years has been "The Promotion of Engineering Education."

While it is out of the question for any one individual to attack this topic with the hope of outlining a complete solution, or even for him to anticipate the many phases that may arise, this topic must necessarily come before our Society for discussion, hence the writer will advance the subject for your consideration in the hope of an eventful thorough treatment.

Realizing that the discussion of our own qualifications is more than likely to be a delicate one, I ask that frankness be not taken for criticism and that the endeavor to call attention to general defects in a goodly number of instructors be not taken to include all.

Throughout this paper an instructor will be understood to be one who *directs* the work in an engineering college, as well as he who *teaches* the technical subjects. This includes those who instruct in engineering, mathematics, physics and chemistry.

For a number of years past, the writer has had frequent conversations with engineering college students, alumni and business men as well as with instructors, representing all of

the well-known schools, and, naturally, the topics discussed included education, methods of presentation and instructors.

These conversations developed a peculiar earnest agreement upon the theme of this paper, consequently the points advanced must be credited not to the writer alone but rather to a consensus of opinion, although he himself wishes to bear the responsibility for this presentation.

The typical engineering college instructor as seen through the eyes of those mentioned may be roughly pictured thus:.

Concerning the moral and physical qualifications there is general agreement that they are very satisfactory. In theoretical teaching the older instructors are credited with strength, each being particularly well read in his chosen line of study—resulting in a productiveness along the lines of notes and text-books. They often continue research in a methodical way, largely from the purely theoretical side, work continuously, but they are not strenuous.

The instructor is usually a fair teacher, pleasant to deal with, but has not the push, drive or ability to handle men, required by the business man—instead there too often appears a tendency to overload the student with work, the fulfillment of which will not ultimately be required. His attitude toward mistakes would not and could not be tolerated in real practice. If the defects were to be summed up, they would come under the more specific head of “Lack of Practical Experience, and Contact with the Practical Side of Engineering.”

To this head then I will devote myself, and attempt to point out: (1) The effect of this lack of experience on the instructor himself; (2) the effect of this lack of practical experience upon the student, alumnus, the professional engineer and the community; (3) some suggestions as to the remedies for this condition.

How does the instructor develop? As a general rule, with the rapid increase in the number of students attending our engineering colleges, it has been necessary to develop instructors from that natural source—the graduates and post-graduates. The more brilliant students are selected to assist in

the so-called elementary subjects, descriptive geometry, mechanical drawing, surveying, shopwork, or in the laboratories. These young men take kindly to it owing to the desire to make use of their knowledge, to the satisfaction of being selected to remain in the college atmosphere, and partially through a fear of entering professional life.

By serious application, with no pedagogical training whatsoever, they develop into more or less efficient instructors. In the two or three years following some are lost to engineering practice, and the more efficient instructors are promoted to the duties of a professorship. In this progress, it is quite usual for some of the more able young instructors to spend a month or two during the summer vacation with a manufacturing concern or in the field, upon duties which unfortunately and necessarily are temporary, mediocre, and not calculated to give that correct insight that the instructing engineer should have into the responsibility and true duties of a practicing engineer.

This experience is followed up more and more infrequently, the older the instructor becomes, until in the later years no such work is undertaken. For proof of this, read over the applications of instructors to membership in engineering societies.

Through his constant and thorough reading along some one line, by investigation, and thought on his specialty, he grows to believe himself to be, and he is, an expert—though far from a practical expert—upon this subject. This develops naturally into a tendency for certain ones to enter themselves in that group of practitioners known as consulting engineers, and experts; in other words they grow to overestimate themselves and the magnitude of their practical accomplishments. Let it be understood here that the professional engineer recognizes that there are upon the faculties of our engineering colleges to-day—*many men* outside of the class above mentioned and upon whom no such criticism can or should be placed. Without mentioning the living, and to give but a single example, who would discredit a man like Robert Thurston?

I doubt whether it is possible for the professional practitioner to have a more thorough comprehensive view of engineering than have some of our educators to-day—men who are persistent in their contact with the practical side of engineering. Yet we are now considering the average instructor—and he cannot avoid average criticism. On the other hand, there seems to be a very large percentage of our instructors who fully realize the situation, who understand that they are decidedly weak, practically admit it, and yet make no effort to correct the mistake. For example, how many instructors of machine design have spent even a month's time upon the floor of a real foundry—in order to get the proper insight into the principle of drafts, supporting of cores, ramming up of the mold and pouring? Is this beneath them? Can they teach design or have the proper viewpoint from which to direct even elementary design without it? I say no. In most cases the design of the instructor may be improved by a professional engineer, by perhaps the addition of a little metal here and the removal of a rib there, which may reduce the cost of casting to one half; both designs look alike—yet how different from the practical side.

How many instructors of surveying could do some of the simpler problems in connection with shop buildings as well from a practical standpoint with a plumb bob and carpenter's hand level, as can be done with an engineer's transit or level?

It is often the realization of these weaknesses that makes a conscientious instructor have what is almost an aversion of making an exhibition of himself. It is easier to read books or take a vacation trip in the woods than to put on a pair of overalls and come in actual contact with the mechanic. You see the result.

The keen foresight of the practicing engineer; the seeing *all around* a question; the "ifs" and "ands" the "buts"; the better and cheaper ways; the swifter and more direct methods; cost and delay due to error; the necessity of noticing even the apparently absurd points as things of importance; the calm and swift decision necessary when things go

wrong—are phases of engineering against which the average professor seldom or never comes. The judgment necessary in the selection of materials for specific purposes that seem paradoxical to an instructor, are axioms to the engineer. The realization intuitively of the nature of strains and stresses, and the rapid, approximate methods of calculation, result only from complete contact with practice over more than a few scattered months. It is these points which when comprehended give an *atmosphere* to an engineer, which would be of infinite value to every instructor, and of incalculable inductive effect on the student.

How does this lack of practical insight affect the student, the alumnus, the business man? Without this atmosphere there will surely be defective teaching. For even though parts of the subject taught at times do not open up the chance to impress upon the student's mind the seriousness of his studies, the instructor inspires more respect, more attention and induces a more correct insight in the student if his own point of view is practical. Is it not certain that students work better for those they know have, and can, accomplish results practically? Does not the student resent being placed under a young instructor not so qualified? How often I have heard the expression in reference to this or that instructor—"He is all right theoretically, but—."

My own experience during five years of college instruction was that every class of engineers may be brought to sharp attention by tactfully introducing some practical theme along the line of discussion; it never failed, whereas a splendid theoretical analysis too often had the opposite effect.

And the alumnus? He follows his college invariably with a loyalty for her welfare stronger than faculties know. Whenever it is noted through the papers that a new man has been added to the staff, the lists of the professional engineers are searched to see who he is and what he has *done* and satisfaction or disapproval follows the investigation. This must indicate that there is a desire on the part of those who are in actual contact with these everyday propositions to have practical engineering instructors in their alma mater.

What the business man too often thinks can be best summed up in what was once expressed to me during a conversation with a well-known engineer: "Yes, I have employed a good many instructors, and all I can say is—I am afraid to use them."

In view of these arguments, gentlemen, is it not vital that steps be taken to improve this condition? These expressions hurt deeply everyone who has made honest efforts to fulfill his place to the best of his ability, for they know that these conditions tend to keep the engineering college instructor and the professional engineer apart. This is not as it should be, and we must take steps to remedy the trouble.

The remedies must be looked for. Naturally it falls upon the deans, or those responsible for the selection of members of faculty, to do their part in keeping constantly on the alert to find men who will better fulfill the requirements of a good teacher and a good engineer. Good men can be induced to accept these positions if certain natural liberties are granted them in the way of permitting such outside work as will, be it distinctly understood, not too frequently and continuously interfere with the prime duty of the instructor.

Again, higher salaries must be paid to attract men of this type. The dean must urge, if not insist upon, his subordinates pursuing some practical work at least every other summer, even though it be at a meager salary. Let him see, too, that the instructor is not so loaded down with duties as to prevent the pursuit of original work without too strenuous effort, and let this original work be of such a nature as may be turned to some practical advantage when time permits of the practical contact. In other words, directors should push out their subordinates into practical ways of thought and action until the exhilaration of real development is felt by both.

The wide difference between the amount of time that can be devoted to both study and practical accomplishment by the professor of history and the professor of engineering should be evident to presidents of colleges. The amount of time devoted by the one to research in books should be compared to the time devoted to practical accomplishment by the other.

Let me ask the deans and head professors of engineering how many are satisfied with their acquaintance with nearby engineering works and their officers? Why is it that firms do not, from one year's end to another, receive a friendly visit from one of the college staff, and why do not the manufacturers visit more often at the colleges of engineering? Unless this interrelation is more fully carried out, can the engineering college best serve the needs of the commonwealth that supports it?

Very fortunately there is developing a closer relation between the various national engineering societies and the engineering colleges. The work of their committees on education will unquestionably assist the faculty materially in bettering the conditions as here advanced. Our instructors must affiliate with, and attend the meetings of these national societies frequently, in order to get the inspiration that follows such contact. With their minds settled on some line of investigation, they will find these meetings full of men ready to talk, advise and even give more material assistance to research, who only wish to know that the instructor is earnest, deserving and pursuing something that is of value to the profession.

In conclusion then, let me assure you, gentlemen, of the deepest interest of all those with whom I have conversed upon this subject. Each has expressed his desire to better the condition whenever possible, yet has felt that natural reluctance of criticising openly, those for whom they have the kindest feelings. Each realized the difficulty of discussing the question without creating a feeling that injustice might be done to many of the engineering instructors. Yet each one felt keenly the desire to have more of a practical engineering atmosphere about the instructor and college.

Upon the question of courses and subjects taught, there was an inclination not to interfere, for they consider our faculties better able to judge of their points than they.

Every member of the society must admit that improvement in the instructors is possible. Whether or not the lines indi-

cated above are the best ones, can be determined only by thorough discussion. I, therefore, submit to this Society the question: Among the requisite qualifications of the engineering college instructor—is not that of a practical atmosphere and understanding one of the most important?

THE SUMMER SCHOOL PROBLEM, PARTICULARLY FOR SURVEYING AND GEODESY.

BY CHARLES DERLETH, JR.,

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There is a marked difference of opinion among engineering instructors as to the necessity, efficiency and value of summer schools of surveying. In existing schools there is much variation in scope of work and methods of instruction. No summer school requirements are found in the curricula of a number of well-known institutions, it being preferred to allow the student freedom for practical work during vacations. In these institutions all field practice is given during the winter terms at the university. In other places the student is given an option either to attend the summer school of the university, or to give evidence of satisfactory practical employment during the vacation period. A third class of institutions conducts summer schools by contracting with a corporation or owner to do surveying for compensation, thus making it unnecessary for the student to defray his expenses. A fourth group of schools make summer instruction compulsory, maintain a nomadic or a permanent site for the camp, and require attendance for from one to three summers.

With such great differences in principle and method it seems clear to me that the subject is worthy of further consideration. Though this Society has devoted in its "Proceedings" much space to the discussion of summer surveying schools no general consensus of opinion has been reached and no distinct decisions have been outlined by any group of instructors. Naturally, the location of a university, whether in the heart of a great city, or situated in country lands, has its direct bearing upon the necessity for summer schools. It is certainly true that a university like Columbia in New York

City requires a summer session for surveying, while a school with a large campus and surrounding property owners who do not object to the use of their lands for surveying during the winter terms has less need of it. But the question arises, would not the schedule of instruction at both types of institutions be benefited by some prescribed summer work. A summer school of surveying, or of railroad and hydrographic practice, or of geodesy, either is valuable or unnecessary. I do not believe that one can claim that the question deserves an attitude of indifference. I do not believe that a student can gain as a rodman for a railroad, the training which it is intended shall be given by carefully outlined practical courses at a university. The freshman or sophomore engineering student hired as an axeman, rodman, or transitman, gains a certain amount of routine practice in a summer's work; but he does not get an opportunity to study the relative accuracies of instruments and the relative merits of different methods of procedure. He does not get the same benefits from his practical employment (despite the salary of \$40 or \$50 per month) that he may obtain by acting as a unit in a railroad party at a summer school where a complete problem is outlined and each student is given an opportunity to test his abilities to solve that problem from beginning to end. In the latter case he has also the privilege of working with his fellows with a chance to exercise his ingenuity and power, to take upon himself responsibilities, to influence and command his associates, and develop his imagination?

The summer school problem is of immediate interest to us at the University of California since we have reached a stage where we believe it necessary to establish a camp at a permanent site with the intention of introducing definitely planned improvements from year to year. In what follows I present: (1) A short history of the surveying camp at the University of California with a partial description of its latest development to make clear our own problems; (2) extracts from comments and expressed opinions recently sent to me by instructors representing a majority of our American schools

of technology; (3) a classified tabulation of surveying summer schools of different types, and (4) my conclusions.

SUMMER SCHOOL OF SURVEYING, UNIVERSITY OF CALIFORNIA.

Our earliest summer session was held at Martin's Mills in 1886. In 1887 and 1888 special classes were taken to the neighborhood of San Jose by Professor W. G. Raymond, now dean of the engineering school of Iowa State College. In the following years the camp was not maintained every vacation period. In 1895 Professor H. I. Randall took a party of fifteen students to the vicinity of Markham, Sonoma County, Cal. Since that date a successful summer school of surveying has been held each year. During the past twelve years its growth has been continuous; and since 1903 it has developed with leaps and bounds. The following table (I.) prepared by Mr. W. N. Frickstad, director of our summer school for 1907, clearly indicates the history and growth of our surveying school. To this table I have added figures for 1908. By combinations of the student maps prepared from field notes we have made elaborate topographical sheets showing the camp properties as used at Point Lobos, 1901-3, and at Liddell Creek, 1904-8. The 1908 school was a great improvement on its predecessors, particularly due to improvements in buildings and equipment and to greater strictness in the enforcement of educational regulations and discipline. The instrumental equipment has been generously enlarged. An up-to-date office building has been erected as a wing to the older instrument building, the cook house has been developed and an efficient water system furnishing running water introduced, etc. But most of the improvements completed this year have been made in such a manner that the camp property may be moved without serious loss.

Our surveying schools are conducted by the Department of Civil Engineering. Freshmen students of all the engineering colleges (mining, mechanical and electrical, civil engineering) are required to attend for four weeks at the close of the freshman year. Civil engineers are required to attend a

second year for four weeks, either to pursue railway surveying problems or problems in hydraulics and hydrographic surveying. These prescriptions normally are satisfied at the

TABLE I.

Year.	Camping Place.	Attendance.*			Director.
		Course 3 A.	Course 3 B.	Total.	
1886	Martin's Mills				W. G. Raymond
1887	San Jose, Mt. Hamilton				W. G. Raymond
1888	Mt. Hamilton				W. G. Raymond
1895	Markham, Sonoma Co.			15 ?	H. I. Randall
1896	Markham, Sonoma Co.				H. I. Randall
1897	Lafayette, Alameda Co.				H. H. Hirst
1898	Calistoga, Napa Co.				L. E. Hunt
1899	Menlo Park, San Mateo Co.	24	4	28	L. E. Hunt
1900	Calistoga, Napa Co.	45	4	49	L. E. Hunt
1901	Point Lobos, Monterey Co.			52	A. E. Chandler
1902	Point Lobos, Monterey Co.	52	12	64	J. H. Dye
1903	Point Lobos, Monterey Co.	61	15	76	C. Loring
1904	Santa Cruz, Santa Cruz Co.	90	22	112	E. N. Prouty
1905	Santa Cruz, Santa Cruz Co.	176	44	220 †	E. N. Prouty
1906	Santa Cruz, Santa Cruz Co.	89	24	113	E. N. Prouty
1907	Santa Cruz, Santa Cruz Co.	201	41	242 †	W. N. Frickstad
1908	Santa Cruz, Santa Cruz Co.	123	47	160 †	W. C. Willard

* For a description of these courses consult the "Announcement of Courses" published by the University Press; also, the Special Summer School of Surveying Prospectus of the Department of Civil Engineering.

† Two sessions. Eleven students (8 in course 3B and 3 in course 3A) performed their work in January, 1907, having been prevented from attendance in 1906 because of the San Francisco earthquake and fire.

end of the junior year. Civil engineering students who elect our railroad course take in addition astronomical field practice for the determination of latitude, longitude, azimuth and time. At present all of this work is done during the winter at Berkeley at the Students' Observatory. It is probable that it will always be so done under the direction of the Department of Astronomy; but in the development of our geodetic instruction we are thinking of introducing geodetic field practice (base line measurements, hypsometry, theodolite angle readings, etc.) for special students, and we believe that such

practice can best be offered at a summer camp. Our present problem, therefore, contemplates a surveying camp at a permanent site for instruction of all engineering freshmen, for civil engineering juniors who take railroad and hydraulic problems, and for special students in railway engineering who propose to emphasize the study of geodesy.

CAMP FINANCES.

The camp finances are handled through two accounts; (1) the university fund, (2) a commissary fund.

University fund.—By regulation each student pays a fee of fifteen dollars for each camp course. For late registration, that is, if the student attends camp later than his regular year, the fee is twenty dollars.

Commissary Fund.—In the past each student paid into a camp treasury twenty dollars. This sum covered his railroad fare from and to Berkeley, and his board for four weeks at camp. Any surplus was returned to the student. In 1907, on account of the prevailing high prices for food products, it was necessary to make an extra assessment of about \$2.50, making a total payment of \$22.50 per individual for the camp session of four weeks. In 1908, the commissary deposit was raised to \$30.00. Of this sum about \$24.00 defrayed railroad fares and living expenses. The balance of \$6.00 was returned to the student at the close of the school unless there were other charges against his account. Extra charges per student may occur in two ways: (1) Fines for breakage of instruments; (2) sundry purchases from our camp coöperative store. The commissary deposit was raised to \$30.00 to insure a balance in the students' favor. Sometimes, but rarely, exceptional breakage or injury to instruments brings a heavy fine upon a student, in which case an additional payment is demanded.

INSTRUCTING STAFF.

In 1908 our instructing and commissary staff consisted of the following officers: a director, five instructors, a commis-

sary agent, a physician, a janitor and three cooks. We employed students to wait on table. Camp was built in the fortnight preceding the beginning of the first session (May 14) and was closed in the week following the end of the second session (July 12). The university employs students to assist the instructors in the making and breaking of camp, paying them at nominal rates for their services.

REQUIREMENTS FOR A CAMP SITE.

In seeking a proper locality we have been guided by the following conditions:

1. The university to control at least two square miles of broken country containing the shore line of a body of water (ocean or lake) and several streams, preferably with a junction of two or more streams; the site to be rich in topography, but not so rough as to lend itself inadequately to railroad and canal problems, or to present unfavorable ground for geodetic base lines; the site to be owned outright or leased for a period of ten or more years. Beside owning or leasing two square miles or more the university to make arrangements with neighboring land owners to allow reasonable trespass on their lands for occasional surveying parties whose work must extend over considerable areas; for example, railroad surveying parties. The property recommended to be sublet for ranch purposes with water rights; the lessee to act as caretaker for the university property and surveying school equipment.

2. An ample water supply providing pure drinking water, water for kitchen and washing purposes, and drainage for a sewer system. A limited system of pipes with intake above camp headquarters to provide running water under pressure in the cook house, dish-washing shed, wash house, shower baths and taps for sprinkling in the neighborhood of the tents and main buildings; further, to supply fire pressure.

3. A bathing place for the students. At Santa Cruz there is an excellent natural ocean beach. An inland camp, to answer this requirement, to be near a large lake or river.

4. To facilitate surveying operations, the camp to afford an absence of underbrush, poison oak and ivy, the property to contain little timber land and to be rich in open country.

5. The site to provide a level place, shaded, protected and centrally located for the building of headquarters. At Santa Cruz this requirement is well supplied by the Liddell Canyon.

6. The site to be accessible to a main railroad line and not more than one hundred miles from the university, with good wagon roads from the nearest railroad station to camp headquarters, and a short haul from station to camp.

7. A large town to be near by, say ten miles distant; to serve as a market for purchasing supplies, and to furnish a telephone, telegraph and mailing center. No community, that is, town, summer resort or roadhouse, to be near the school.

8. The site to enjoy an equable climate; that is, freedom from prevailing winds, thick fogs, extreme heat or intense cold.

The Santa Cruz site answers almost all of these requirements, the exceptions being: (1) Want of ownership; (2) lack of a lease; (3) high winds in the afternoon; (4) considerable fog.

SURVEYING SUMMER SCHOOLS AT OTHER UNIVERSITIES.

The subject of summer schools of surveying has been generously discussed at past annual meetings of the Society. A number of descriptive articles with discussions have appeared in the "Proceedings."* At the Society's meeting in St. Louis in 1904, Professor A. Marston, of Iowa State College, made clear the reasons why practical surveying schools cannot be alike at different institutions. He said in part: "Local conditions exert a large influence to affect engineering courses at different institutions and in no particular is this more true than in instruction in field surveying. Evidently, an institution located in the heart of a great city can have small opportunity for carrying on field work, while college is in

* Consult Volumes I., XII., and XIII.

session, in direct connection with its class-room work, and may be forced to transfer practically all of its field work to the summer surveying school. The Iowa State College, on the other hand, owns over eight hundred acres of land in one body, and is located in a country district where the surrounding private land owners do not object to the carrying on of surveys over their lands by students. The conditions are, therefore, very favorable for carrying on a considerable part of the field work in direct connection with the class-room work in surveying and railway engineering.”*

Professor H. C. Ives, of the University of Pennsylvania, in a discussion of Professor Marston's paper,† makes the following statement: “There are four different ways of arranging the theory and field work in surveying. First, where the recitation work is given during the term, supplemented by sufficient field work to give the students a clear understanding of the construction and use of the instruments, and possibly by a longer continuous session during the summer. Second, where the recitation and lecture work are given during the term time with no field work, all field work being given in the summer session. Third, where no recitation or field work is given during the term, both being given in the summer school, a lecture preceding the field work of the day, with examinations at intervals. And fourth, where the men are started in field work before the opening of the fall term and before recitation work has been given, but with sufficient directions for its successful conduct.

“The first of these methods is pursued at the University of Pennsylvania, the second at Columbia University, the third at Harvard University, and the fourth at the Sheffield Scientific School of Yale University.

In October, 1907, we sent a circular letter of inquiry to instructors at every engineering school in the country, requesting that they give us certain information relating to their ideas of summer instruction in surveying. We received a

* See “Proceedings,” Volume XII., page 131.

† See “Proceedings,” Volume XII., page 143.

large number of replies, of which about twenty discussed the question in considerable detail. In the following paragraphs I refer to statements from these letters. The statements are summarized in the succeeding paragraphs and the schools have been arranged into three groups.

I. Summer field work conducted in the country immediately before or after the boarding season, using boarding houses as headquarters.

1. New York University; at Kingston, New York.

"Two classes are taken, the junior and senior. The junior class makes a complete topographic survey covering an area of several square miles, also a hydrographic survey of a portion of Rondout Creek. The seniors make all the surveys up to and including the location of a railroad.

"We do not have individual problems. The classes are organized at the start as any large surveying corps would be on an extensive survey, and this organization is maintained to the end. We board at summer boarding houses, which up to the present time have answered our purposes. We have no property of our own nor do we lease any. We use the country at large, of course obtaining permission of property owners to cross their land. Our classes are reaching such a size that we shall soon have to arrange other means of quartering them."

2. University of Pennsylvania; in the mountains of Pennsylvania.

"Surveying at this institution is given only to students in civil engineering, and is not taken up until the sophomore year. The change from the freshman to the sophomore year was made some years ago and has proven very satisfactory. Descriptive geometry, which formerly was taken in the sophomore year, is now taken in the freshman year. The change was prompted by two considerations:

"First, that the freshman mathematics enabled a student to take up surveying to better advantage.

"Second, that the weakest material in the class is eliminated in the freshman year, to the relief of the instructors of sur-

veying and to the advantage of the remaining members of the class.

"We devote four hours a week to surveying field practice throughout the sophomore year; three hours a week for one half of the second term to railroad surveying field practice. This is followed by a four week's period in the field devoted to hydrographic, topographic and railroad surveying during the month of June at the end of the sophomore year. Aside from a little field work in connection with the senior course in geodesy the above schedule covers the time devoted to field work in our course.

"In my judgment the requirements of the subject are satisfactorily met by our schedule, and I feel disinclined to extend the time devoted to field work; first, because the majority of the upper classmen obtain employment in engineering during the summer and are thus enabled to add to their capital, both financially and professionally; and second, I see no justification for over-emphasizing surveying field work as is done, in my judgment, at a number of institutions, as compared with the training received in other subjects. To make my point clear let me say that I would feel better justified in holding one of the upper classes for four weeks during the summer to be devoted to one or more subjects other than surveying. Doubling the period now devoted to field work would not, in my opinion, result in a gain in anyway commensurate with the expenditure of time.

"We make our headquarters at one of a half dozen hotels at Eagles Mere in the mountains of Pennsylvania during the four weeks preceding the opening of the season at that summer resort, which enables us to obtain moderate prices. Our classes in the past have not exceeded sixty, although next year the number may be increased to ninety."

In my reply to these statements I made, among others, the following comments:

"Two summer school periods are not excessive; one in general surveying for freshmen or sophomores; the other in railway or hydrographic work for juniors. I should hesitate to

require of students four separate summer periods as is now the case at one institution with which I am familiar.

“Three years ago we transferred our courses in elementary surveying to the freshman year. Our experience seems to have been quite different from yours (University of Pennsylvania). To make the change it is a coincidence that we reversed your action; that is, descriptive geometry, shades, shadows and perspective, were advanced from the freshman year to the sophomore. We find descriptive geometry rather difficult for freshmen. On the other hand elementary surveying helps their mathematics. It certainly strengthens their trigonometry, their knowledge of logarithms and their ability to compute.

“Many students who attend the engineering schools at the University of California must make their own way. My experience leads me to conclude that more students who earn their own living attend western institutions than eastern ones. Elementary surveying in the freshman year helps these men materially. Many of them stay out of college for a year or more after completing the freshman work. Those who finally come back are most desirable students. For those students who remain continuously at the university we find that freshman surveying has an advantageous effect also. Mathematics, physics and chemistry, which represent the backbone of the freshman year are pure subjects, but the student unfortunately does not always appreciate their bearing sufficiently. Surveying, however, to a large extent, blends theory with practice and tends to excite or to increase the interest of the incoming sophomore who is over anxious to see the engineering application of his studies.”

3. Washington University, surveying school near St. Louis, Missouri.

“Our work is very similar in its scope to yours, except that we have a three-weeks session each year and only the civil engineering students are required to take this work. Our facilities evidently enable us to engage in more practice on the campus than you are able to accomplish. Conditions in

this part of the country also enable us to give the student considerable practice in hydrographic surveying. We go to a summer resort habitually, at a time of the year when the summer boarders are just leaving and so take advantage of hotel accommodations.”

4. University of Wisconsin.

Surveys are made at Portage on the Wisconsin River. The students board in private families. Portage is a city of about 6,000 inhabitants.*

5. Lehigh University.

“We do not have a camp but take our students to towns nearby in the mountains where they board at hotels and neighboring houses for about one month at the end of each college year. This work is in topographic surveying and is required of all students in civil engineering, also of all students in mining engineering. No extra tuition is demanded for this school, but of course the student pays his own traveling expenses, board, etc.”

II. *Surveying work done near the campus or upon it; mainly during term time.*

1. University of Syracuse; Syracuse, New York.

“When the civil engineering course was started at this institution we contemplated the establishment of a summer school of some kind, but the developments so far have been unfavorable to carrying out the plan. On this account no regular summer school of surveying has ever been started. We make a practice, however, of closing the class work of the junior year about the first of May and devoting the entire remaining time between that and commencement to field work. The location of the university, moreover, with open country near at hand, is particularly suitable for carrying on field work during the session.”

2. University of Missouri; Columbia, Missouri.

“At present we have no summer school of surveying and,

* See description of this school by Professor Leonard S. Smith, “Proceedings,” Volume XIII., page 63, 1905.

therefore, I am unable to comply with your request to send you printed instructions, regulations, etc. We have under consideration a summer school in surveying and I am very glad to get some details of your work."

3. University of Minnesota; Minneapolis, Minnesota.

"The college of engineering offers no summer school of surveying at the present time. It is very possible that such a course may be offered in the near future. The only work here at the present time corresponding to what you offer is that described in the Bulletin of the School of Mines; all sophomore mining engineers are required to take the summer school field work.

4. University of Colorado; Boulder, Colorado.

"All our surveying work is done during the academic year."

III. *Work done at an established camp or summer school of surveying.*

1. Columbia University; camp near Litchfield, Connecticut.

"Columbia prepares each year an elaborate prospectus giving complete announcements of the summer courses in surveying. The summer camp is well developed in buildings, equipment and courses. In 1907 four distinct courses were offered: (1) General elements of surveying, five weeks, required of all first-year students in chemical engineering, metallurgy, mining, civil engineering. (2) Advanced surveying, five weeks, required of second-year students in civil engineering, metallurgy and mining. The work is differentiated for the needs of the respective engineering departments. (3) Hydrographic surveying, two weeks, required of second-year students in civil engineering. (4) Railroad surveying, required of second-year students in mining engineering and third-year students in civil engineering. The work is differentiated to the needs of the two departments.

I am informed that the geodetic summer work heretofore conducted at Osterville, Mass., is to be done in the future at the Litchfield School. This work is required of third-year

students in civil engineering. In the past the length of the course was four weeks. The purely astronomical practice dealing with the use of the sextant instrument, the transit instrument, etc., for the determination of latitude, longitude, azimuth and time is now done at the university observatory during the winter months. In the past a considerable part of it was done at the summer school and may probably be still so done there.

Columbia University also conducts mining, metallurgical and geological summer schools in districts suitable to the respective purposes, varying in locations from year to year.

A description of Columbia's camp as it existed in the early nineties (1893) is given by Professor Henry S. Munroe, professor of mining and founder of the surveying camp.* In a discussion of the same topic by the Society twelve years later, 1905, he states:† "In some respects our scheme of work differs radically from that adopted elsewhere. We do not attempt to make maps for publication, nor do we undertake extensive surveys requiring the coöperation of large bodies of students. Such surveys and maps necessarily burden the instructors and consume time which might be employed to more advantage in their legitimate work of teaching. Our surveys and field exercises are designed solely for educational purposes, and in each case we endeavor to accomplish the result in the simplest possible way. Each of the earlier surveys is preceded by special exercises designed to teach the student the manipulation of the instruments to be employed and some of the details of the field method to be used in the next survey. The course of instruction is progressive and each survey prepares the student to some extent for those that follow."

2. University of Michigan; an excellent, simple camp.

"Your organization seems to me to be excellent; numbers cannot be handled without it. I am doubtful if I can add anything of service to you. We began this kind of work in 1874. Our first camp was in 1877. Our number last summer

* Consult "Proceedings," Volume I., page 243.

† "Proceedings," Volume XIII., page 79.

was 77, all civil engineers. No other students were allowed except by special permission. Our discipline is strict. We would make it stricter if we knew how; not in petty ways, but in administration. Our schedule for six days in the week is as follows: 6:50 A.M., roll call; 7:00, breakfast; 7:45, inspection of camp; 8:00, work begins; 12:00, lunch (usually on the work); 1:00, work begins; 5:00, quit; 6:00, supper; 10:00, lights out. Camp quiet except below.

"Instruments, tools, in fact all parts of our outfit, are issued on brass checks. There is no bookkeeping, therefore no bother. 7:30 to 8:00 A.M., store tents are open for the issue of equipment: 6:30 to 7:00 P.M., for receiving the same. At other times the store tents are closed.

"Heads of parties write up field notes on office blanks which are afterwards fastened in a loose leaf book. These men must work until their task is done. They may have lights but must keep quiet. They are quiet enough. They are striving to get through. Theoretically, when the last man goes into his blankets at night everything is finished up to that day and time. We have the fewest possible rules. Tents are separated by wide spaces. Our fees are \$20.00 in all. Students pay their own board. Board is \$3.75 per week, and is furnished by a boarding boss: at present a woman.

"Our camp is such as might be permanently occupied on a work of long continuance. We believe that the camp and the camp discipline are a large part of the surveying lesson."

3. Iowa State College.

At this institution students who obtain responsible and approved summer positions with engineers are excused from summer school attendance. The remaining students for several years have conducted surveys of a lake in the northern part of Iowa, each year work being begun where the preceding year's closed. In earlier years surveys were made in a similar manner of stretches of the Des Moines River.

"The Civil Engineering and Mining Departments of this division conduct summer surveying schools following commencement each June. The schools continue for two weeks

and are merely supplementary to the work of the course during the term time in field work. Students who secure engineering employment during the summer months are excused from these summer schools. We have for this work a complete camping outfit but do not go to a definite site each year.”*

4. Ohio State University.

This institution also excuses students who get summer employment. The regular summer school of the university is arranged each year, or whenever possible, to perform an actual piece of work for some person or corporation. For the surveys the university class receives some payment which is applied toward the expenses of the school. There is therefore no permanent camp site.

“At this school only civil engineering students are required to go to camp. The requirement first went into effect in 1900. The sophomores and juniors go the Friday preceding commencement, about June 15, and stay four weeks.

“During the first three encampments (which were held at different places in the rough southeastern portion of the state, about eighty miles from the university) the work was administered under substantially the same arrangements as those set forth in your circular with the differences incident to the courses as here given during the academic year. Our sophomores have ten exercises to do on the campus in land and city surveying in the fall term, and eight in railroad surveying in the spring term. They followed this in camp with elementary railroad surveying for two weeks; then land surveying for two weeks. Our juniors have three topographic maps to make in the fall terms and also the work outlined in Professor H. C. Lord’s book on astronomy during the fall, winter and spring terms. They followed this in camp with advanced railroad and topographic surveying. The drafting was done in the evenings by all, after the field work for the day was completed. The problems were imaginary railroad lines, etc.

* Consult an article by Professor A. Marston describing the field work at Iowa State College, “Proceedings,” Volume XII., page 131, 1904.

"In 1903 in an endeavor to put the field work in still closer touch with practice we accepted a proposition to survey several thousand acres of coal land in southeastern Kentucky, employing those students who had not elsewhere secured field work for the summer with practising engineers. We have been following this plan since, excusing from camp those students who secure suitable engineering work with some practising engineer. We find some advantages in this method:

"1. The excused student gets three months' experience during the summer in place of one, and although he does not usually get the variety, he gets a more thorough drill.

"2. He gets paid for his work, which makes it real and enables him to help himself financially.

"3. It heightens his sense of responsibility. This is often needed by the younger students.

"4. It extends his acquaintance among practising engineers and engineering companies; a benefit upon graduation.

"5. The excused student must file a statement covering the details of the work for which he asks credit, to which is pinned a blank filled out by his employer. These form the evidence upon which the amount of credit is based. In this way the department conducts an employment bureau and usually only twelve or fifteen students out of the hundred otherwise due are left to go to camp. During the last four encampments we have been using these campers on practical work as follows:

"In 1903 nine students and three instructors surveyed about 2,000 acres of coal land in southeastern Kentucky for an Indianapolis syndicate. In 1904 no summer work was done by any department at the university. In 1905 with thirty-two students and four instructors we surveyed and mapped topographically forty-two miles of the road system in Yellowstone Park. For this the national government paid subsistence and transportation during the survey. In 1906 with thirteen students and two instructors, surveys, plans and estimates were made for street improvements and sewer sys-

tem at Willoughby, Ohio. At the completion of the work the town voted the necessary bonds and construction was begun, several of our men being retained to engineer the work. This past summer (1907) eleven students and two instructors re-ran center line and made inventory plats of eight miles of the C. P. & E. Electric Railway and made surveys and maps for five miles of street improvements out of Cleveland, Ohio.

"The camp incidental fee has been \$20.00 during the past years, which covers subsistence and transportation. To this the university during the past three years has added a laboratory fee of \$6.00. However quite a sum is always rebated, some years covering nearly the whole deposit on account of the compensation received for work done by the camp. The university furnishes the entire camp outfit down to and including cots and a portion of camp incidentals, such as lumber for camp dining tables, tent floors, etc. Each student provides his bedding, clothing and personal outfit."

5. Harvard University.

An elaborate school at Squam Lake, New Hampshire.

"We have a camp at Squam Lake for instruction in surveying, railroading and some other subjects in engineering, like mechanics and descriptive geometry. This camp consists of a number of farms on the slope of Red Hill which is in Moultonboro in New Hampshire. There are about 500 acres of land with two miles of lake shore line available and belonging to the university, purchased for the purpose of building up a camp. The cost of this property was in the neighborhood of \$6,000.

"There are various buildings—one consists of a number of large rooms intended for what might be called administration, and general use of all students. The mess hall is located there; the kitchen, and near by the ice-house. Close to the general hall is another building for an instrument room and drafting room. To this place we send the instruments at the beginning of every summer and return them in the fall. Not far away is a room for drafting which is simply a one-story wooden building with the entire north side filled in with glass.

There is considerably more to the establishment that I should be glad to tell you if you desire.

"The students customarily go to the camp in June just after examinations and remain until the end of the first week in September. The cost for this length of time per student was last summer \$102.50. This amount for each student pays all the expenses of the camp, so that it is self-supporting. The students live in tents and are thus out of doors all the time.

"The lectures begin at seven o'clock in the morning and usually one lecture is given before the students go into the field, where they customarily remain for from eight to nine hours. There are other lectures in the afternoon, but not regularly."

6. Yale University.

Two sites near New Haven owned or controlled by the university; one for elementary surveying, one for railroad work. Yale also has a forestry school and a mining school.

"Sheffield Scientific School controls a large strip of land about three miles long and a mile wide, about six miles from New Haven, easy to reach by trolley or train. Our students are required to spend, before the opening of the college year, three weeks surveying from eight in the morning until five at night. The office work, mapping, etc., is done after the opening of the academic year. By this method we are free from all trouble and expense connected with the running of a camp. The students live in New Haven and carry their lunch to the field. For mining engineers where a different type of work is desired we have a similar locality a short distance from the city in a mountainous district. Students in forestry go to a camp in Pennsylvania. Here a limited number of students spend eight weeks in a camp provided with suitable buildings. The camp is under the control of the Yale Forest School and is designed more especially for forestry than for surveying."

7. Cornell University.

In the past Cornell's school was located on the "finger

lakes'' of New York State. In later years it has been located on Fall Creek where the students each year are adding to an elaborate survey of the watershed of that creek for the purpose of obtaining data for Cornell's hydraulic laboratory.*

"Our work now is limited to the junior class and it lasts four weeks and three days, beginning the fourth day of block week or of the examination period. No tuition is required, but a deposit of \$25.00 is made to pay board, tent rent, etc. The work used to be conducted on the 'finger lakes' of central New York where there were summer hotels vacant at the time that the work was done, and hence available for boarding places. For the past eight years the work has been on the watershed of Fall Creek for the purpose of determining the watershed for a study of run-off in connection with our hydraulic laboratory. No suitable hotels are available so that we live in camp. The work is progressive from year to year and the maps and elevations are worked up as a continuous piece for publication. We have no difficulty with reference to the health of the students. Our camp is kept in sanitary condition each year, while the site for the next year is a new one, so that we have nothing to fear from the previous year. An effort is made to make this work as nearly like actual practice as possible. It has always seemed to me that the students and instructors could both take the work more nearly in the spirit of actual practice if the ground and the problems were new each year. In a locality like this where so much of the ground is under cultivation, it would not be possible to go over the ground year after year unless the university owned the land. As it is, we have but little difficulty with property owners as we are careful to do as little injury as possible and to cultivate their good will.

"Our field work in elementary surveying and curve work in railway surveying is done on and in the vicinity of the campus. Our work in railroad location is done in the fall in the vicinity of the university on Saturdays, extending out in

* See their prospectus and a paper by Professor Charles L. Crandall, "Proceedings," Volume XIII., page 71, 1905.

different directions in different years for a radius of about ten miles. The camp work takes up topographic surveys, precise levelling, triangulations, base lines and about two thirds of the work given in practical astronomy. The field maps are reduced and the computations made for the finished map in the senior year, giving credit of two hours in cartopography.

"The students elect their own chief engineer; a commissary agent and captains for the different parties are appointed by the instructing staff."

The University of Minnesota and the Michigan College of Mines conduct summer schools of surveying, but only for mining students. These schools are naturally located in mining districts and are not necessarily permanent in site from year to year.

My correspondent from Michigan College of Mines writes: "We have no summer school work corresponding to that about which you write. Our regular course in surveying, which is given during the summer months, does not take the class out of the vicinity of the college. Students are able to return to the regular boarding houses each evening. In the spring of each year a class in mine surveying is taken to the iron district about sixty miles from here, but while there the students board in private families or hotels, as they choose."

The University of Nebraska conducts no summer school of surveying. It prefers to allow its students to get summer employment.

"We have no summer school of surveying in connection with the University of Nebraska, and have not at present in contemplation the establishment of such a school. One principal reason why we have not considered this matter in any favorable light is that the majority of our students have had one or more seasons of outside practical experience before they graduate and it has seemed to us that such experience is of as much advantage to them as the instruction which we could give them by holding them during the summer."

CONCLUSION.

It is clear to me from the evidence presented that the opinion of a given instructor is largely influenced by the peculiar environment of his university. The reader will notice that a number of the statements quoted reflect directly and indirectly the problems presented at the author's institution. It will be granted, I think, as a unanimous conclusion that the character of a surveying summer school, its scope of work and duration, must be shaped by each school according to its needs. But can it be best to have no summer work at all?

It is my judgment that every engineering school conducting courses in civil engineering should maintain a summer school. Preferably two courses should be offered, one in the elements of surveying for freshmen or sophomores; the other in railroad, canal and hydraulic problems for juniors. Mining schools naturally would substitute mine surveying for the second course. Geodetic instruction in general would only be given by the larger schools and to special students.

It cannot properly be claimed that employment in a subordinate position of a practical field party is a satisfactory substitute for the instruction given in a well-organized university surveying course. Both experiences are very valuable to the engineering student; they supplement each other. They can be had in alternate years. They are not alike. With rare exceptions the one is routine practice, the other ought to be a scholarly test of principles, a study of degrees of instrumental precision, a comparison of methods and instruments, a training in computation and mapping, and last but not least, the best opportunity offered at the university to get close to instructors and fellow students. Camp life gives the largest opportunities for the students to learn to know one another; it provides some of the happiest days of an undergraduate career.

REPORT OF COMMITTEE ON NECROLOGY.

THOMAS GRAY.¹

Late Professor of Dynamic Engineering, Rose Polytechnic Institute.

Thomas Gray, first professor of dynamic engineering of the Rose Polytechnic Institute, served from September, 1888, to the time of his death, December 19, 1903. He was born February 4, 1850, in Lochgelly, Fifeshire, Scotland, and received his primary education in the schools of that district. He was apprenticed in handicraft for several years, and entered the University of Glasgow, graduating in 1878 as B.Sc. in engineering. He became experimental scholar under Lord Kelvin, then Sir William Thomson. While in the university he gained many distinctions in the classes of engineering and mathematics, receiving several prizes. Shortly after graduation he was awarded the Cleland Gold Medal of the university for An Experimental Determination of Magnetic Moments in Absolute Measurements.

In 1879 he was elected professor of telegraph engineering and demonstrator in the physical laboratories in the Imperial University of Tokyo, Japan. He had as colleagues Ayrton, Perry, Milne, and Myer. He contributed a number of papers, during this period, to the Royal Societies of London and Edinburgh and a number of papers to the philosophical magazines. The first papers were upon experimental work in heat and electricity.

While in Japan he became interested in seismology and wrote a number of papers on earthquakes and earthquake measurements, some in collaboration with Professor Milne. He invented several forms of apparatus for the measurement of earthquakes. In 1881 he returned to Scotland and entered the laboratory of Lord Kelvin and Professor Jenkin, assisting in the manufacture and laying of the Commercial Company's two Atlantic cables. He took part in all the expeditions of the *Faraday* made in connection with the undertaking. After the completion of his task he again returned to Kelvin's laboratory and became his assistant. During this time

¹ Biographical statement prepared by President C. Leo Mees, of Rose Polytechnic Institute.

he aided in the design and manufacture of the well-known Kelvin balances, and published a number of papers on electrical measurements. He wrote the article on the electrical telegraph and telephone for the "Encyclopedia Britannica."

In 1888 he became Professor of dynamic engineering in the Rose Polytechnic Institute, which position he retained until his death. He organized the department of dynamic engineering and published a large number of papers dealing with strength of materials, electrical and magnetic measurements, etc. He was the editor of the articles referring to electricity and magnetism in the "Century Dictionary," and also prepared the Smithsonian Physical Tables, published in 1896 and revised in later years. At the time of his death he had in preparation a text-book on electrical engineering which unfortunately remains unfinished. His services as an expert in mechanical and electrical engineering and in patent litigation were widely sought. He was a most careful experimentalist, accurate and ingenious in inventing devices for research, and rarely have any of his results been questioned. His writings are models of direct, clear exposition. As expert he invariably showed a commanding knowledge of the subject. As teacher he was attractive, and presented the subject under discussion in such a masterly manner that the student who was otherwise prepared could not help but follow in its development.

He was a member of the Royal Society of Edinburgh, the B. A. A. Sc., the A. A. A. S., A. I. N. A., S. P. E. E., A. S. M. E., and other societies, in most of which he held office. Some fifty papers upon scientific and engineering subjects of which he was author are catalogued.

[Professor Gray served two full terms as a member of the Council of the Society and was in his third term at the time of his death. He was also vice-president in 1900-1901.—Ed.]

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